Vignettes of the Santa Barbara Area

The United States as seen from Santa Barbara, California by Waldo Tobler

Prepared for the 2001 Annual Meeting of
The Association of Pacific Coast Geographers—Santa Barbara, CA

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Introduction

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This volume is part of the permanent record of the Association of Pacific Coast Geographers' meeting in Santa Barbara in September of 2001. We feel that it represents the unique flavor of the distinctive character of our beautiful part of the country. To the outsider and visitor, Santa Barbara seems the stuff of beach movies and soap operas. Our Mediterranean climate is, of course, perfect (though check out the full wording of the song "It never rains in Southern California"). Our mountains are picturesque, our ocean bountiful, the quality of life high.

Yet, Geographers know well that regions are distinct, and that global problems have local impacts. In this volume, some of the historical, cultural, natural, and physical elements of the South Coast are illuminated by those in a position to know the facts. Borrowing from the immense intellectual capacity of the University of California, Santa Barbara, we offer treatments on the geology, tectonics, landslide geomorphology, and hydrology of the area. It becomes quickly apparent that California and hazards go hand in hand, and that, in many aspects, we inhabit a region of immense environmental stress, perhaps best shown by the water issue here. In more ways than one, we live life on the edge.

From the human side of geography, this volume includes a set of case studies of humankind's role in changing the face of the earth, from cultural and historical landmarks, to the open space issues of the foothills, to the threats to our oaks and forests, to the vernal pools and the kelp forests of the ocean. The threats are driven, of course, largely by human demographics. The trouble with paradise, of course, is that everyone wants to live there! Visible behind all of these issues is the role of Geography. The insightful reader will soon see that, even in Santa Barbara, we have our problems.

Yet we also like to feel that in Santa Barbara we pioneer solutions. The guides to some of our resources, the Map and Imagery Laboratory at UCSB, and the trails and bike paths of the region show some of the things we do well here. We also hope that you will agree that we also know how to host a conference. As Chair of the Department of Geography at UCSB, I wish you a productive and memorable meeting in Santa Barbara. Please enjoy the papers in this volume and use them to better appreciate the wonderful place you are visiting. And then, of course, come back again.

A Succinct Economic and Demographic History of Santa Barbara

by
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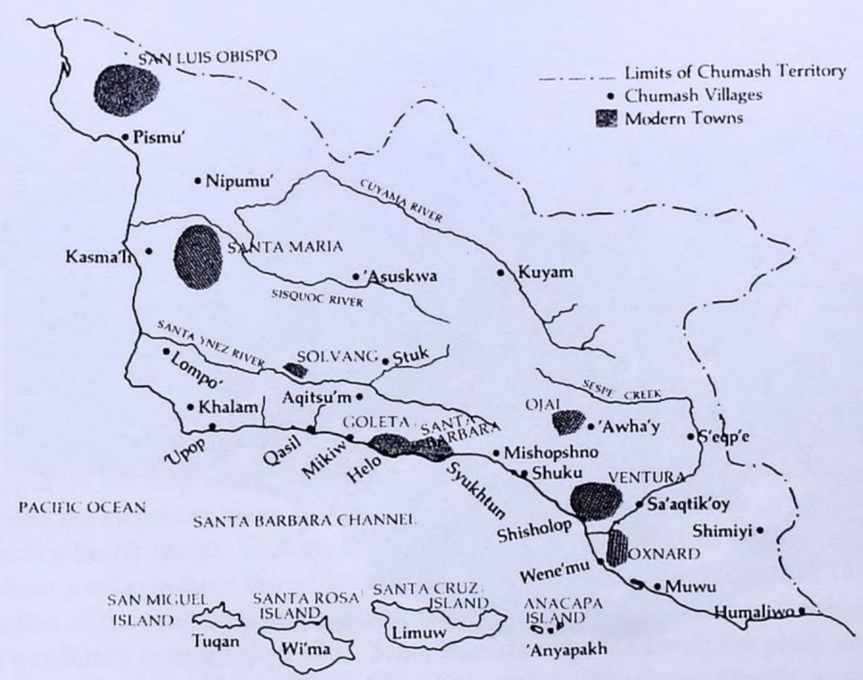
Santa Barbara County, in the words of noted historian Walker Thompkins, sits astride "California's Wonderful Corner." Blessed with abundant sunshine and incomparable beauty, and isolated by steep coastal bluffs and rugged mountain ranges, Santa Barbara County has long been viewed as a unique opportunity to build paradise in California by the various cultures that have settled the area over the generations.

This brief overview of the history of Santa Barbara focuses on some of the fundamental shifts in the composition of the population, its settlement structure, and its economy. Inconsistencies in the definitions of variables used in census counts back to 1860 prevent an exact characterization of the population or its economy. We have attempted to judiciously blend material from the censuses with historical accounts to describe some of the fundamental changes in the region's character from the time of the Chumash tribes up to the present. Though the paper does not attempt a serious analysis of those changes, we do offer a set of demographic and economic challenges facing the current population of Santa Barbara County.

Early Years: Villages, Rancheros, and Statehood
The region currently known as Santa Barbara County was the home of California's most prosperous tribe, the Chumash [Fig. 1]. The first European explorers marveled at the quality of the Chumash canoes used to ply the waters between the mainland and the Channel Islands. Together, these lands supported the densest population of Native Americans found anywhere on the continent. Gidney, et al. (1917) claimed that the population could not have been "below 22,000", while other estimates have been far higher. The Chumash economy was based primarily on fishing and trade; they were highly regarded for their skill in basket-making.

Figure 1: Chumash Villages, 1750



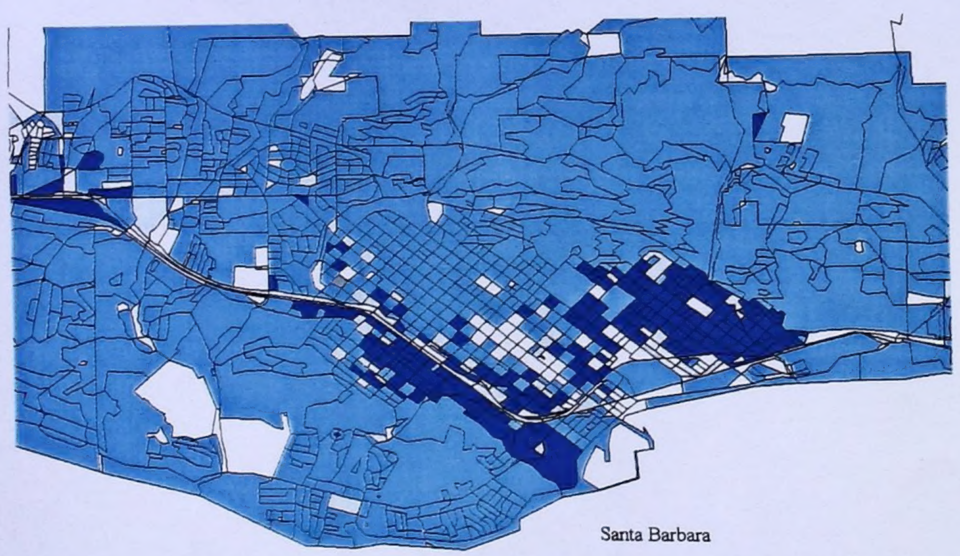
Reprinted with permission from The Chumash People, published by the Santa Barbara Museum of Natural History

The period of Spanish domination began with the establishment of the Santa Barbara Presidio in 1782 and the Santa Barbara Mission four years later. Many Chumash were rounded up by the Mission and forcibly introduced to Western notions of religion and agriculture. Ultimately, the effort to convert the natives into self-sufficient Christians was largely unsuccessful. Despite ample herds of cattle (16,598 head by the peak of the mission system around 1814) and bountiful crops of wheat, corn, and beans, the missions were unwilling to give up control over the native peoples. By 1824, many natives had either perished from exotic diseases such as smallpox, or had risen up in revolt over mistreatment. Additional missions set up at La Purisma (Lompoc) and Santa Ines (Solvang) fared little better.

The advent of Mexican independence in 1822 ultimately led to the secularization of mission holdings, starting in 1834, as a way of cleansing the Spanish influence from the region. Unfortunately, the secular administration turned out to be ineffective and incompetent, and many Chumash fled. This led to the collapse of the mission economies and hastened the division of mission holdings into ranchos, which we were given to those favored by the Mexican government, frequently military generals.

Although California became American territory after 1848, and a state two years later, the *Californios* were allowed to keep the ranchos given to them by the previous Mexican government. However, rancheros were forced to pay property taxes and wages to their laborers for the first time, which forced them into the market economy with all of its associated whims. At first, this was not a problem, since the gold rush provided a strong market for cattle in northern California. As the gold fever waned, the fortunes of the *Californios* turned for the worse. The extreme drought of 1864 finished off many of the remaining rancheros. Only 5,000 out of 250,000 head of cattle across the county survived the year. American buyers swooped in to grab the ranchos at cheap prices, many of whom wound up subdividing the property for development. Santa Barbara County was overwhelmed by white, American settlers, though the Spanish and Mexican influences on the region were certainly formative of latter developments in the economy and settlement structure. The cultural heritage of Spanish and Mexican habitation still dominates the cultural landscape of the region. Moreover, there are many direct descendents of those early residents, and the Latino population of Santa Barbara county is still dominant throughout many parts of the county, with vibrant localized ethnic communities such as the Milpas area shown in the 2000 census data (see Figure 2).

Figure 2: Hispanic Concentration In Santa Barbara, 2000

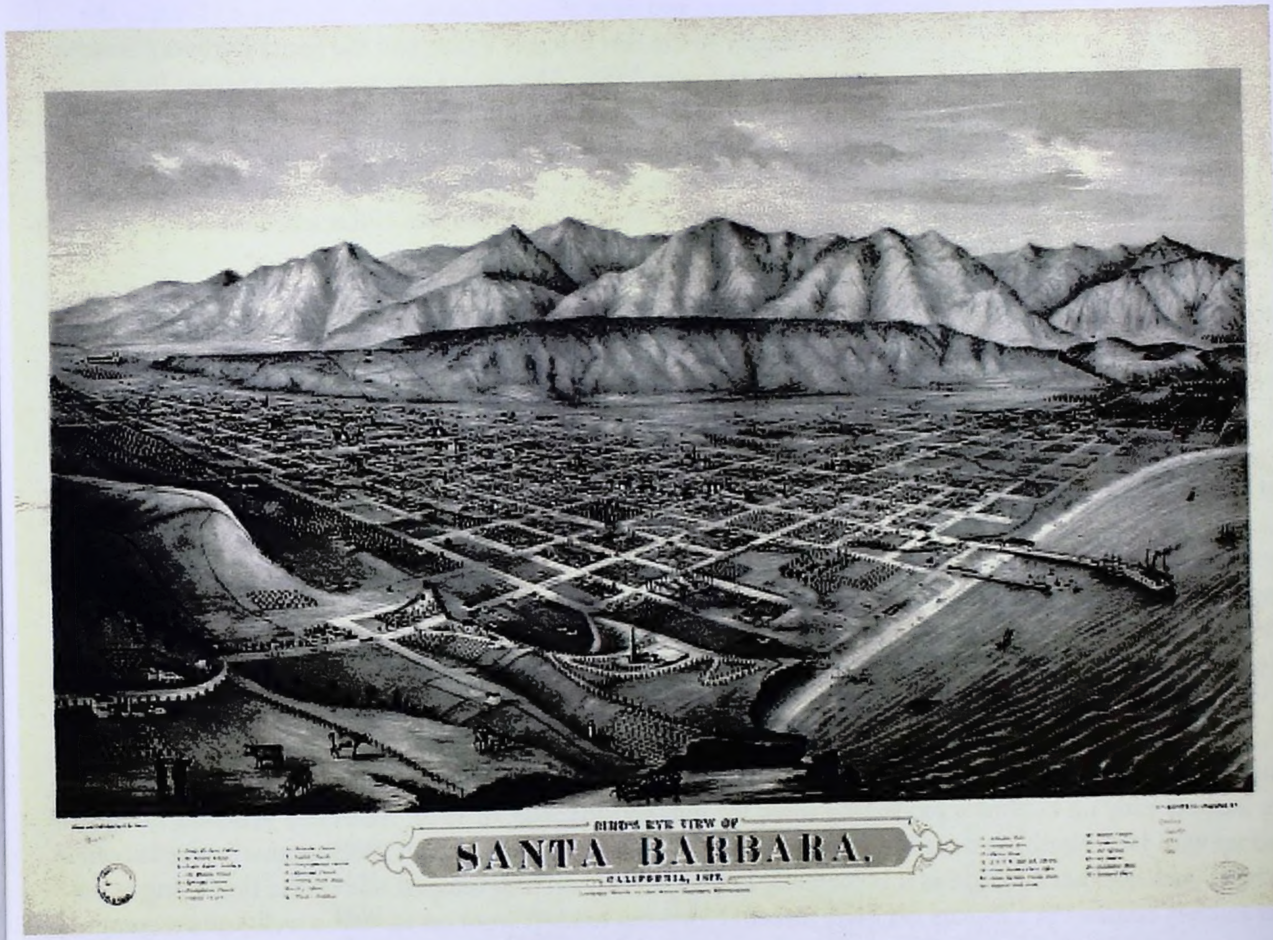


Note: The areal boundaries in this map are census blocks. The black blocks are fifty percent or more white/non-white Hispanic and the gray blocks fifty-percent or more white non-Hispanic.

Amenity Drives Growth: 1870 Through World War I

For the first two decades of American rule, Santa Barbara was a largely sleepy town, without so much as a railroad or even a bank. By the 1870s, necessary developments were taking place that would transform Santa Barbara County, especially the South Coast, from a quiet backwater region to a vibrant economy. In 1872, Stearns Wharf was completed, which greatly enhanced Santa Barbara's image as a viable seaport. The wharf is clearly evident in the bird's eye view of the town in 1877 (see Fig. 3). During the great 1880s land boom, the Southern Pacific Railroad was persuaded to build the first railroad into Santa Barbara from Ventura County. The first train rolled into Santa Barbara in August 1887. As part of the overall improvement, the city paved State Street and installed an electric lighting system during the same year. Plans for extending the line through to San Luis Obispo were put on hold when the economy plunged shortly thereafter. Wagon trails over San Marcos pass to Los Olivos remained the only way to reach San Francisco until the railroad was finally completed in 1901.

Figure 3: Panoramic Map of Santa Barbara, 1877



Santa Barbara was put on the map in 1873 when Charles Nordhoff wrote a highly publicized series in *Harper's Weekly* which extolled the virtues of Santa Barbara's near perfect climate. Virtually overnight, Santa Barbara was transformed into a health resort. Cashing in on the industry, Colonel William Hollister opened the opulent Arlington Hotel about a mile up from the wharf in 1875. The economic slowdown after 1887 not only prevented the completion of the Southern Pacific Railroad; it also made a new resort unfeasible. Sure enough, when the railroad was finally completed in 1901, Santa Barbara responded with the plush new Potter Hotel, which, unlike the Arlington, focused mainly on affluent patronage. The Potter Hotel's success stimulated the growth of Montecito on the east, and, later, Hope Ranch to the west, and the health resort aura of the Arling-

ton led to the creation of the Cottage Hospital. In the end, resorts like the Arlington and the Potter Hotel were done in by the convenience of auto travel. The Potter burned down in 1921, and the revamped Arlington was damaged in the 1925 earthquake – neither was rebuilt.

Santa Barbara County has always been known for its favorable climate, but, by the end of the 19th century, it was becoming clear that it was also blessed in its geology. In 1898, a major oil strike in Summerland led to the world's first offshore drilling effort. The results were mixed; although the Southern Pacific was just beginning to convert its trains from coal to oil, motorcars were still several years away, and the market for petroleum was still questionable. Three decades later, the Ellwood oil strike once again placed Santa Barbara County in the forefront of national oil production. This time, the automobile industry provided a limitless market for consumption. Additional strikes at Mesa and El Capitan solidified the South Coast reputation for bountiful oil. Other parts of the county proved equally fruitful. During the 1930s, oil production increased in the northwestern part of the county, especially near Santa Maria and Cat Canyon. In 1948, Richfield came across a large field in Cuyama Valley at the very north end of the county, and even plotted a new town to serve it. During the 1950s, profitable oil production was moving largely to the San Joaquin Valley and the Santa Barbara Channel, with the first offshore platform commencing operation in 1958. Although a sanctuary was created for the shoreline between Summerland and Goleta in 1955, critics claimed the oil platforms were likely to increase pollution. Although the January 1969 blowout of Platform A filled the channel with a heavily-publicized and massive oil slick, offshore oil drilling was still the extraction method of choice through the 1990s. However, attempts to build additional platforms and rigs by Arco and Mobil during the late 1980s and early 1990s were vigorously opposed.

Motion Pictures are not often associated with Santa Barbara County, but, during the second decade of the 20th century, Santa Barbara was briefly the movie capital of the world. In 1912, the American Movie Company decided to set up shop in downtown Santa Barbara to film several Western one-reelers. The following year, the company erected the Flying "A" Studios (so called after the company's logo design), which was the largest motion picture studio built up until that time, and even featured the first indoor studio lighting system. Several other studios briefly sprang up in the city, including the Santa Barbara Motion Picture Company. For several years, the Flying "A" Studios produced some of the most widely-viewed films, largely Westerns, in the world. Ultimately, the growing concentration of movie studios in Los Angeles and the collapse of the American Movie Company's distribution system led to a decline starting in 1917 and culminating in the complete closure of the studio by 1920. Later attempts to revive the studio failed, and it was eventually turned into a skating rink before being demolished.

Formation of the Aviation-Education Complex: World War I To 1970

Santa Barbara early on became a pioneering town for military aviation. In 1916, Allen and Malcolm Loughead joined up with Jack Northrop to create Loughead Aircraft Manufacturing, which later became better known as Lockheed (and Lockheed Martin as it is currently known). Early on it developed one of the first flying boats under military contract in a factory off State Street. Northrop himself went on to start a well-known company of his own after a brief stint with Douglas Aircraft. By 1941, Santa Barbara was building a new airport in Goleta Slough, as its downtown facility was unable to handle the growing traffic. The advent of war in December led the military to take control. Santa Barbara Harbor was requisitioned by the Navy, as was the airport which was hurriedly completed in 1942. In addition, the Marines utilized the Mesa opposite the airport, and the Army created Camp Cooke west of Lompoc. After the war, the military handed back control of all but Camp Cooke, which eventually became Vandenberg Air Force Base in 1957 and one of the most important launching facilities for ICBMs and satellite reconnaissance craft. The creation of Vandenberg led to massive population growth in nearby Lompoc (5,520 in 1950 to 25,284 in 1970) and Santa Maria (10,440 in 1950 to 32,749 in 1970), which, until the 1950s, were largely known for agriculture and highway services [Fig. 4; Table 1]. In the years since, Santa Barbara County has continued to attract military contractors and associated high-tech firms,

notably Raytheon, with many of them located in a corridor abutting the Santa Barbara Airport known as "Silicon Beach."

Figure 4: Population Growth in Santa Barbara County, 1850-2000

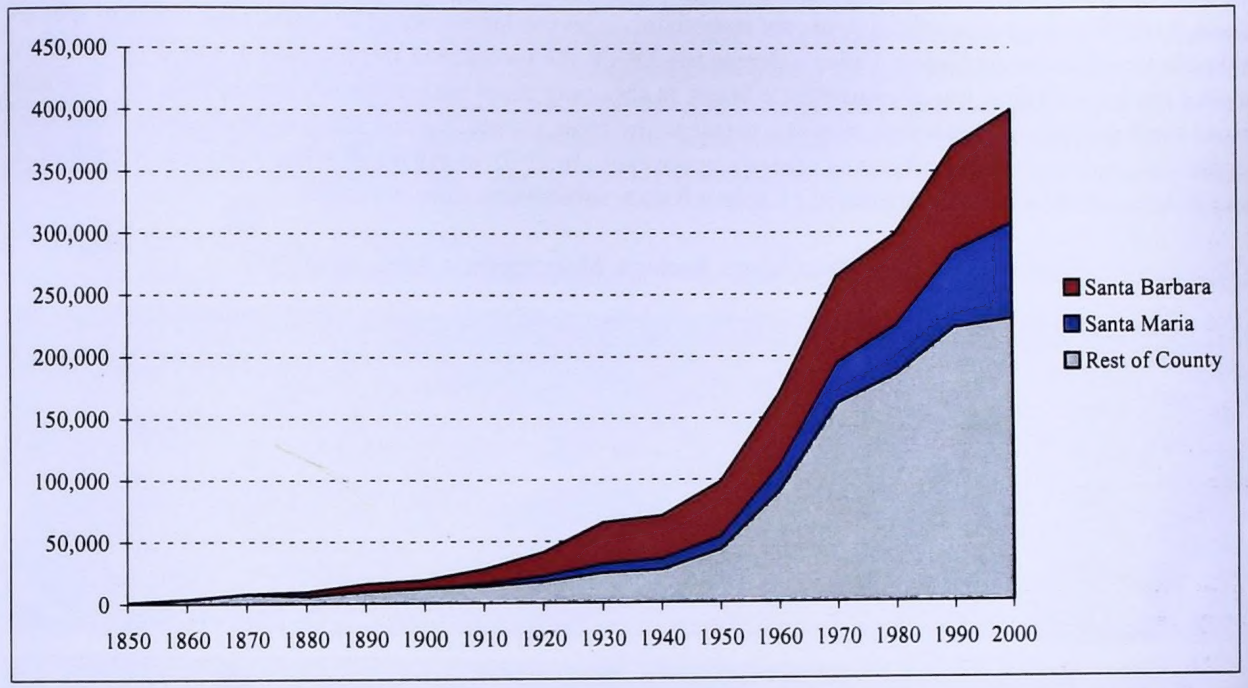
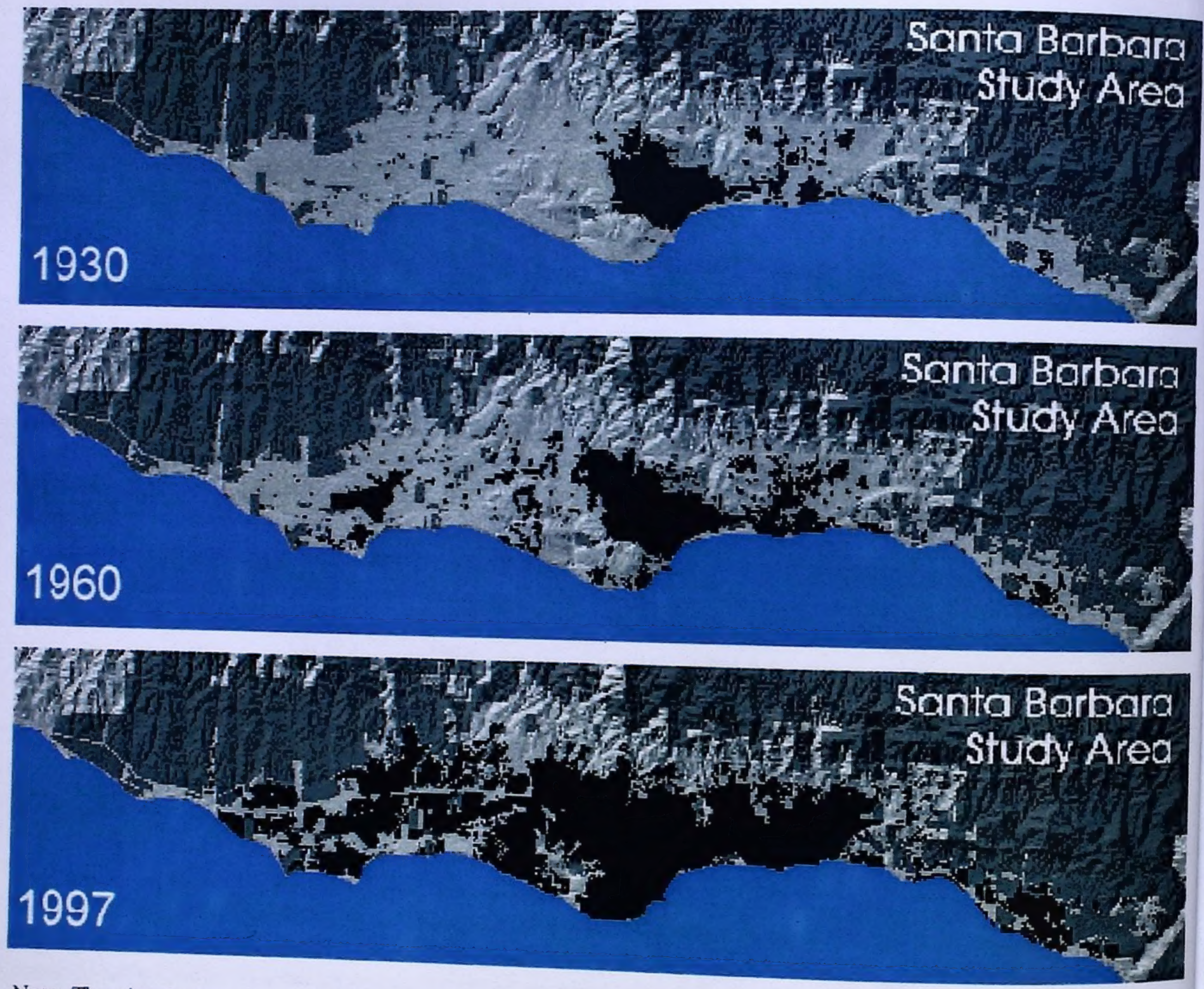


Table 1: Selected Santa Barbara County Populations, 1850-2000

	Santa Barbara city	Santa Maria city	Rest of County	Total
1850			1,185	1,185
1860			3,543	3,543
1870			7,784	7,784
1880	3,460		6,053	9,513
1890	5,864		9,890	15,754
1900	6,587		12,347	18,934
1910	11,659	2,260	13,819	27,738
1920	19,441	3,943	17,713	41,097
1930	33,613	7,057	24,497	65,167
1940	34,958	8,522	27,075	70,555
1950	44,913	10,440	42,867	98,220
1960	58,768	20,027	90,167	168,962
1970	70,215	32,749	161,360	264,324
1980	74,414	39,685	184,595	298,694
1990	85,571	61,284	222,753	369,608
2000	92,325	77,423	229,599	399,347

The spectacular growth of college-level education in Santa Barbara has had a similar influence on development. Originally located on the Riviera behind downtown Santa Barbara, Santa Barbara College moved to the former Marine camp on the Mesa by the airport in the 1950s. By 1958, it became a full-fledged member of the University of California system alongside UC Berkeley and UCLA. The number of students gradually increased from 3,000 to well over 10,000. The university student population is currently nearing the 20,000 student cap agreement with Santa Barbara County. In addition, Santa Barbara City College was established in a former campus of Santa Barbara College along the downtown waterfront. The establishment of UCSB in Goleta led to wholesale development along the Goleta Valley – during the 1960s, the population there tripled in size [Fig. 5]. What was once Hollister Avenue was renamed State Street as shopping malls such as La Cumbre sprang up. The sudden and rapid growth of Goleta was seen as a threat to the quiet coastal life that many Santa Barbara residents took pride in, and became the subject of severe controversy. In 1970, in the wake of the Platform A oil spill, a countywide referendum killed a planned El Capitan Ranch subdivision west of Goleta.

Figure 5: Growth of Santa Barbara Metropolitan Area, 1930-1997



Note: These images were created by Keith Clarke and are related to his urban growth modeling research. They are used with his permission Black indicates urbanized/developed property, light grey indicates undeveloped property that has no development restrictions, and the dark gray is national forest area.

Closely related to the growth spurred by the military and educational sectors was the issue of water supply. During 1948, a severe drought forced Santa Barbara County to consider the construction of additional water resources. Gibraltar Dam, which had been completed in 1919, supplied water from the Santa Ynez Valley through the Cold Spring Tunnel to the Santa Barbara area. For years, that was seen as adequate. By the late 1940s, more capacity was clearly needed. Bradbury Dam was completed in 1953, creating Lake Cachuma which fed Santa Barbara via the Tecolote Tunnel under the Santa Ynez Mountains. Further north, the Twitchell Reservoir was created along the Cuyama River to generate additional supply for sprawling Santa Maria and for more intensive agricultural practices. Many critics saw additional water supply as a license to build more houses. Starting in the 1970s, resistance to further water supplies strengthened. In 1972, a moratorium was placed on additional water hookups in Goleta which effectively put a brake to urban growth. Although developers cried foul, the public was firmly behind efforts to limit the availability of water. In 1979, voters across Santa Barbara County firmly rejected a plan to pipe in additional water from Northern California – one of the very few counties to offer any objection to such a scheme.

The Struggle Over Growth: 1970 to Present

The infamous oil spill of 1969 galvanized environmentalist in the state and region; it has also been characterized as the initial shot that ultimately led to the creation of a national, and then global, environmental movement. Santa Barbara was an early focus of the movement – the first Earth Day was held in Santa Barbara in 1970, when activists briefly closed Stearns Wharf in protest over drilling practices. Issues of oil spills and drilling platforms began to merge with general concerns over suburban sprawl and water capacity. The resulting movement against growth and increased water resources effectively checked major development in Santa Barbara from the early 1970s to the mid-1990s.

The drought years from 1986 to 1991 prompted Santa Barbara County to reconsider its position against increased water capacity. Water recycling became a major source of irrigation for landscaping at parks and golf courses starting in the late 1980s. At the height of the drought in 1990, Santa Barbara constructed a desalinization plant to convert seawater into additional water reserves. In 1993, work finally began on a Coastal Branch of the California Aqueduct to connect Santa Barbara County to Sierra Nevada water. The project was completed in the summer of 1997.

With the addition of major additional water sources, Santa Barbara County is once again faced with the issue of growth, especially in the area around Goleta and the Gaviota Coast. In 1996 the County Board of Supervisors removed the limit on growth in Goleta, which, combined with the new Coastal Branch of the California Aqueduct, reversed the anti-growth restrictions in place since the early 1970s. Growth in the Goleta Valley has picked up, and the last half of the 1990s witnessed the construction of the 83-acre Camino Real Marketplace and the opening of the $220 million Bacara Resort, the latter following a lengthy battle against strong environmental opponents. To the east, developers are now eyeing large-scale residential development in Toro Canyon between Montecito and Carpinteria. Santa Maria also saw the opening of a major mall, the Crossroads Shopping Center, during this time.

Concerned that the momentum for growth is gaining once again, environmentalists have redoubled their efforts in recent years to oppose development. In the wake of the loss at Bacara, controversial efforts have arisen to declare large portions of the Gaviota Coast a national park. The local planning department, working in conjunction with local environmentalists and ranchers, has successfully arranged to buy the development rights for some of the large land holdings on the Gaviota coast. The Toro Canyon Plan was crafted to balance demands for housing with environmental protection, although its implementation has been held up by bitter disputes between environmentalists and landowners.

Important Issues For The Future

The growth restrictions in place in South County since the 1970s have contributed to a sharp increase of the cost of living in the Santa Barbara/Goleta area. The median housing price was nearly $600,000 in 2000 and is expected to increase its upward trend. Many workers at places like the Bacara Resort need to be bused in from North County. How will the need for affordable housing impact efforts to restrain growth in South County, especially

along the famed Gaviota Coast?

Although Santa Barbara County is seen as an ideal place to live, population growth is exacerbating natural hazard that have long plagued the area. The list of recent disasters includes the 1925 earthquake, the 1990 Painted Cave Fire, and the floods of 1995. Is Santa Barbara County adequately prepared to meet these challenges to its continued growth and prosperity?

Growth in Santa Barbara County, especially along the South Coast, has led to a major increase in traffic congestion. U.S. 101 was expanded to three lanes west of Santa Barbara during the 1980s, and the famed stoplight at State Street and U.S. 101 was replaced by an overpass in 1991. Pressure is growing to widen the freeway along th Montecito-Carpinteria corridor. Opponents say this will merely encourage new growth. Will the county be able balance the need for smooth traffic flow with the desire to restrain runaway suburban growth?

The conservation movement is spreading beyond the Gaviota Coast to the Channel Islands. Plans are afoot to ban fishing within the Channel Islands National Marine Sanctuary altogether. Can the environmental movement and the fishing industry coexist in the future in Santa Barbara?

Santa Barbara County has seen many economic booms in its history, ranging from oil drilling and agriculture to a large university and a major Air Force base. The 1990s witnessed a spectacular amount of growth in the high-tec sector, particularly in aerospace. Yet Santa Barbara County still has pockets of substandard housing and underem-ployment. Will future industries bring more widespread wealth to the county, or will the gap between the rich an poor continue to grow?

In recent years, opponents of oil drilling have scored major successes, such as the drive to stop the erection of a large oil platform near Devereux Beach in 1995. Still, the area around the Santa Barbara Channel remains an enti ing prospect for future oil projects. Will future environmental challenges to the petroleum industry be equally su cessful, especially in light of the current energy crisis?

In recent years, growth in Santa Barbara County has largely occurred north of the Santa Ynez Mountains, especially in Santa Maria and Buellton. Although the trend has slowed somewhat, it is predicted that the North Coun population will exceed that of South County by around 2010. Santa Barbara County is increasingly becoming po larized between the low-cost housing, younger population, and ranch/agriculture economy in the north and the well-to-do, older population in the south. How will this affect the future economic growth and political balance Santa Barbara County?

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Physical Geography of the Santa Barbara Area

by

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Physical Geography of the Santa Barbara Area

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Introduction

Santa Barbara's geographic position is unique in several ways. It lies on the longest stretch of east-west trending coastline on the west coast of the United States. The ocean is to the south, and going down the coast means traveling almost directly eastward. Depending on one's point of view, Santa Barbara is either at the northern end of southern California or at the southern end of central California. Move 40-50 miles down the coast and the outlying settlements of the Los Angeles-San Diego megalopolis clearly signal southern California. Move 40-50 miles up the coast around Pt. Conception and both the natural and human environments are central Californian. The physical environment has elements of both regions, and, for the purposes of this discussion, the Santa Barbara area will be expanded a hundred miles or so in each direction to clarify relationships with similar and contrasting natural features outside the immediate area.

The geologic history of most of the region is short but very active. Recent and ongoing folding and faulting have produced young mountain ranges with steep slopes and rugged topography. The climate is Mediterranean, dominated by unrelenting summer drought and highly variable winter rainfall, by substantial temperature variations ranging from cool coast fogs to extremely hot interior deserts to cold high elevation alpine zones. There are probably few places in the world which have such a diverse set of physical environments in a comparable area. This diversity is at the heart of the appeal of the region but, at the same time, produces the hazards for which the area is infamous—the earthquakes, floods, fires, landslides, etc.

Geology

Southern Santa Barbara and Ventura Counties occupy the western end of the Transverse Ranges. The mountain ranges in this geologic province have the distinction of being one of only two ranges in the United States that trend east-west. As a result, the coastline runs almost directly east-west in contrast to the dominant north-south orientation of the rest of the Pacific Coast. The westernmost range in the province, the Santa Ynez Mountains, forms the backdrop of the city of Santa Barbara and extends westward to Point Conception. The Transverse Ranges continue eastward into the Topatopa and Pine Mountains of central Ventura County, the San Gabriel Mountains in Los Angeles County, and the San Bernardino Mountains. Elevations generally increase eastward, starting with maximum elevations around 600 meters (2000 ft) at the western end, rising to 1300 meters (4200 ft) behind Santa Barbara, 2300 meters (7500 ft) in the Pine Mountains, 3000 meters (10000 ft) in the San Gabriels, and 3500 meters (11500 ft) in the San Bernardinos. The Channel Islands to the south of Santa Barbara are extensions of the Santa Monica Mountains of Los Angeles County.

In the northern portions of the counties, the Transverse Ranges merge with the southern end of the north-south trending Coast Ranges which parallel the coast northward to the Oregon border and beyond. The San Rafael and Sierra Madre Ranges of northern Santa Barbara County are generally considered to mark the southernmost extent of the Coast Ranges geologic province. To the north, the Santa Lucia Range is responsible for the spectacular coastal scenery of Big Sur as it rises to heights of more than 1000 meters (3300 ft) just a few kilometers from the shore.

Even though maximum elevations in the region are not spectacularly high, the terrain is frequently very rugged. As a result, there are a number of isolated, road-less areas within short distances of significant population centers and heavily traveled roadways. The Santa Lucias, for example, are crossed by only one minor road in a distance of around 175 kilometers (110 miles). Similarly, there is only one road heading north out of Santa Barbara and Ventura Counties between Highway 101 and Interstate 5.

All of the Transverse and southern Coast Range provinces are west of the San Andreas fault zone. The region lies on the Pacific Plate and is being rafted northward as that plate moves past the North American Plate. The ruggedness of the terrain is, in part, a result of the fact that the uplift of the current mountain ranges is very recent in geologic terms. All of the tectonic activity which produced the ranges in both provinces has occurred in the last 5 million years (Pliocene and Pleistocene Epochs).

In fact, the whole geologic history of the area is quite short. The oldest rocks are from the Franciscan formation of the late Jurassic to late Cretaceous Periods (roughly 150 to 75 million years ago). This formation is prominent in the Coast Ranges, but its origin was a mystery before the development of the theory of plate tectonics. It is a complex *melange* of sedimentary and volcanic rocks, all apparently deposited in deep ocean environments. It is now thought that this formation originated in a subduction zone produced as the Pacific Plate collided with and dove beneath the North American Plate. This was apparently the same event as the Nevadan Orogeny which produced the granitic rocks of the Sierra Nevada and the original Nevadan mountains on the site of the Sierra Nevada.

The rocks which make up the western Transverse Ranges are mainly from the Eocene, Oligocene, and Miocene Epochs (53.5 million to 5 million years ago). Most are marine sandstones and shales, indicating that the area remained beneath the sea for most of this period. For example, the sequence in the Santa Ynez Mountains behind Santa Barbara includes the Juncal and Matilija sandstones, the Cozy Dell Shale, and the Coldwater sandstone from the Eocene Epoch (53.5 million to 39 million years ago). The one major non-marine formation is the Sespe which consists of floodplain deposits and is Oligocene in age (39 million to 23.5 million years ago). This formation is absent in the western Santa Ynez where the marine rocks continue throughout the Oligocene, indicating that the coastline ran through the region somewhere.

By the beginning of the Miocene Epoch (23.5 million years ago), the sea had advanced back over the whole region. The Rincon Shale is the main formation of the early Miocene. This formation weathers into unstable clay soils which are prone to sliding and tend to swell and shrink substantially as moisture is added and removed. A number of Santa Barbara neighborhoods, particularly in the foothill areas, are built on these soils and have experienced significant problems as a result.

During the middle of the Miocene (15 to 10 million years ago), deep marine basins formed throughout what is now coastal California between San Francisco and Orange County. These basins apparently resembled current features in the Gulf of California which is being split open by the spreading zone associated with the East Pacific Rise. It is thought, therefore, that the appearance of the basins may have signaled the passage of the area over the spreading zone. This is also about the time the San Andreas fault became active in this part of California, suggesting a shift in relative plate movements from the colliding which produced the earlier subduction features to the shearing tangential movements associated with the modern San Andreas transform fault. The rocks formed in these basins (the shales of Monterey Formation) are composed largely of organic material rather than terrestrial sediments. Much of the material is silica derived from diatoms which are microscopic phytoplankton. The Monterey Formation is usually finely bedded and is exposed in many of the coastal bluffs in the Santa Barbara area.

The uplift which elevated the present mountain ranges in the area began during the Pliocene Epoch (5 million to 1.8 million years ago). The Santa Ynez Mountains were lifted by a combination of folding and faulting along the Santa Ynez fault just north of the crest of the range. The structure of the range does not follow the rock strata which have been tilted 90° or more and which cross the crest of the ridge tangentially. As a result, one moves through successively older strata going north up San Marcos Pass. At the base of the mountains, marine conditions persisted into the Pleistocene (1.8 to million to 10,000 years ago) as the youngest rock, the Santa Barbara Formation, was formed. The coastal plain probably emerged from the sea less than 1 million years ago. Frequent earthquakes and substantial deformation of recent alluvial deposits are compelling reminders that the uplift is continuing.

There is a considerable amount of interest in the cause of the east-west trend of the Transverse Ranges. The San Andreas fault, which forms the northern boundary of the province from Ventura County to San Bernardino

County, deviates from its typical northwest-southeast trend to parallel the Transverse Ranges. There is no generally accepted explanation for the bend, but it clearly creates strong compressive forces as the land west of the fault pushes against the westward bend in the fault. Evidence from paleomagnetic studies done by researchers in UCSB's Geology Department suggests that the Transverse Ranges west of the San Andreas fault rotated clockwise 60° to 80° between 16 and 6 million years ago, possibly because of shearing along the Pacific-North American plate boundary. This does not explain why the east-west trend continues through the San Bernardino Mountains which are east of the San Andreas fault.

Petroleum has long been exploited in the area. Tar from natural seeps was used in pre-contact times by the local Chumash to seal their boats. There are a number of natural seeps still active, particularly offshore from Coal Oil Point just west of UCSB, and small blobs of tar are a common fixture on many local beaches. The Transverse Ranges have been a fertile area for oil and gas exploration since the 19th century. Major discoveries were made around the end of the last century in Ventura and the Santa Barbara Channel. The latter was the first offshore field developed in the United States when it opened in 1896. It also gained considerable notoriety when a well blew out in 1969 and produced the first major offshore oil spill in the United States.

Climate

The climate of all of coastal California is Mediterranean, with a strong alternation in precipitation between dry summers and wet winters. More than 90% of the annual precipitation falls in the November-April period. Amounts generally increase northward, with San Diego averaging about 25 cm (10 inches), Los Angeles 40 cm (15 inches), Santa Barbara 45 cm (18 inches), San Luis Obispo 55 cm (22 inches), and Big Sur State Park 100 cm (40 inches). This large scale trend is strongly modified by topography. Almost all precipitation is produced by large-scale mid-latitude storms moving off the Pacific, so west and south facing slopes are relatively wet, as average precipitation generally increases with elevation. Leeward slopes and interior valleys show strong rainshadow effects. In Santa Barbara County, for example, precipitation rises from 45 cm (18 inches) at sea level to 75 cm (29.5 inches) at 670 meters (2200 feet) on San Marcos Pass to 92 cm (36 inches) at 1900 meters (6300 feet) on West Big Pine Mountain. Meanwhile Lompoc in the Santa Ynez Valley averages 36 cm (14 inches) and the Cuyama Valley in the interior of northern Santa Barbara County averages only 18 cm (7 inches), technically making it a desert. Snow levels typically range from around 1000 to 2000 meters, so most precipitation in lowland areas falls as rain. Occasionally, unusually cold storms will produce snow down almost to sea level, but only the higher elevation regions of the San Gabriel and San Bernardino Mountains accumulate significant snowpack.

Coastal central and southern California and the adjacent mountain ranges have exceptionally large interannual variability, so averages must be interpreted with care. At many stations, rainfall totals in the wettest years are as much as ten times greater than in the driest years, and the range extends from one-third of the mean to more than 2.5 times the mean. The driest and wettest winters in the 125 year Santa Barbara record are 11.5 cm (4.5 inches) and 114.8 cm (45.2 inches). The majority of winters are relatively dry with around 60% falling below the average, but occasional winters can be exceptionally wet. These wet winters are almost always characterized by a period of several weeks of persistent heavy rains produced by a sequence of very large warm, wet storms moving in out of the southwest. They are often associated with El Nino conditions in the equatorial Pacific, although the link is not entirely consistent and the mechanisms are not fully understood. Rainfall totals can be very high, especially on south-facing slopes at middle and high elevations. In January of 1969 Santa Barbara received 51 cm (15.5 inches), while 92.7 cm (36.5 inches) fell at San Marcos Pass, and Juncal Dam at 630 meters (2060 feet) in the upper Santa Ynez Valley received 112.5 cm (44.3 inches). A single storm in a twelve hour period in January, 1995, produced 20 cm (8 inches) in downtown Santa Barbara and as much as 50 cm (20 inches) in the higher elevations. Rainfall of these quantities and intensities, when combined with the steep slopes, shallow soils, and sparse vegetation cover characteristic of the area, can produce severe flooding and landsliding problems.

In contrast to the high variability in winter rainfall, summers are remarkably uniform in their drought. Less than 5% of the average annual precipitation falls between May and October, and less than 1% in June, July, and August. Furthermore, only once in the last 125 years has more than 2.5 cm (1 inch) of rain fallen in Santa Barbara in July or August. The wettest July in 115 years at Los Angeles produced only 6 mm (.25 inches) of rain, and 110 have had

less than 1 mm (.04 inches).

The reason for this persistent drought is that the North Pacific High pressure cell moves north and intensifies in the Summer. It produces strong subsidence and blocks the westward penetration of moist, unstable air masses from the Gulf of Mexico and Gulf of California, which move north out of Mexico into the interior Southwest. The strong high is also responsible, along with the relatively cold ocean temperatures, for the inversion and coastal fog which persist throughout the summer. Air near the ocean surface forms a cool, moist marine layer within which fog typically forms. The marine layer is capped by an inversion with a warmer, drier layer of subsiding air above. Since air only rises as long as it is warmer and less dense that the air around it, the inversion effectively puts a lid on the lowest layer of the atmosphere. This phenomenon greatly exacerbates the air pollution problems in the region because pollutants do not disperse upward through the inversion.

Coastal fog and cold ocean water have a moderating influence on summer temperatures at coastal stations, where average maximum temperatures are around 20°C (68°F). The cooling influence diminishes rapidly moving away from the coast, however, and average daily maxima in interior valleys are 35°C (95°F) or above. This temperature difference produces strong sea breezes which blow inland off the ocean, typically peaking in the afternoon. The winds are very dependable and can be quite strong in areas where they are concentrated by topography. A number of wind power farms have been established in areas where there are gaps in the mountain barriers separating coastal and desert valleys.

Winter temperatures tend to be mild in lowland areas, especially along the coast where sub-freezing temperatures are uncommon. Interior valleys are generally colder, and low-lying areas frequently become frost pockets due to cold air drainage. Frost-sensitive crops such as avocados are most commonly grown in coastal areas and in thermal belts on the slopes above the colder valley floor. If air masses are moist enough, fog will form at night in the valley bottoms. In most of coastal California, this radiation fog will burn off during the day, but in the Sacramento and the San Joaquin Valleys, where it is known as tule fog, it can persist for days or even weeks at a time. This type of fog produces severe hazards for traffic, because it tends to be most dense in low spots. Small drops in elevation can result in significant reductions in visibility. Large chain reaction accidents involving 100 or more vehicles are not uncommon.

Another distinctive weather type which occurs in spring and fall is the Santa Ana wind. When the typical pressure distribution of high pressure over the eastern Pacific and low pressure on the continent is reversed, a circulation can develop which brings hot, dry desert air out of the northeast into southern California. The general flow is perpendicular to the Transverse ranges, so the winds get funneled through passes and accelerate downslope toward the coast. In addition, compressional heating increases temperatures and reduces relative humidities—often to less than 10%. These strong, hot, dry winds create severe fire hazards, especially in fall when the natural vegetation is already dry after the long summer drought. Any fires started in the open chaparral-covered hill and mountain areas of southern California quickly grow into large conflagrations which are impossible to contain until the winds die down, often 3 or 4 days later. Fires of this type have probably always been a natural part of the chaparral ecosystem, but they have been responsible for major property damage as people have built more and more homes (often large and expensive) in the hills.

Biogeography

The complex climate, geology, and topography of the Transverse Ranges and southern Coast Ranges combine to create very diverse and fragmented biogeographic patterns. Within 200 miles of Santa Barbara, vegetation communities range from nearly barren desert scrub to dense redwood forest, from subtropical palm oases to alpine meadows. This diverse set of modern environments, along with Pleistocene climatic change and continental movement on the order of 100 km over the last 10 million years, have probably all contributed to produce the relatively high rates of endemism (species with very restricted ranges) observed among plants and animals of the region.

The unrelenting summer drought is one fundamental climatic constraint common to all of the region, no matter

how wet or dry or warm or cold, which all plants and animals must adapt to. Southern California vegetation, in particular, is distinctive in its abundance of drought-adapted scrub vegetation, mainly different types of Chaparral. Chaparral-like scrub communities are characteristic of Mediterranean climates throughout the world, although species compositions change from region to region.

Pronounced slope effects complicate efforts to subdivide scrub communities, but several reasonably distinct types can be associated with differing climatic zones. Coastal Sage Scrub grows at low elevations and, as the name implies, does best in maritime climates where summer fog is important. On the other hand, such areas generally have lower winter precipitation than foothill and mountain areas, so Coastal Sage Scrub is very drought-adapted. In fact, some of the community's plants and animals are also found in the desert, and others have close relatives in the desert.

Coastal Sage Scrub is sometimes referred to as "soft" Chaparral because many of the plants have soft, flexible leaves and branches. Most shrubs grow about knee-high, making them relatively easy to walk through in marked contrast to other Chaparral communities. One of the most common species is California sagebrush, *Artemisia californica*, which is drought-deciduous and closely related to Great Basin sagebrush, *Artemisia tridentata*, the most common plant of the Great Basin Desert. Another common species is coast brittle-bush, *Encelia californica*, which is closely related to desert brittle-bush, *Encelia farinosa*. Several species of true sages, *Salvia* spp., are also common drought-deciduous elements of the Coastal Sage Scrub. Common species include black sage, *Salvia millifera*, and purple sage, *Salvia leucophylla*.

Most of the sage species, as well as some of the other shrubs, have strong, pungent odors and flavors. It is interesting to note that many of the herbs commonly used in cooking originated in the Mediterranean climates of the Old World. There are several good local substitutes, including Cleveland sage (fragrant sage), *Salvia clevelandii*, and California bay, *Umbellularia californica*, a riparian tree in southern California.

Considering the affinity of the Coastal Sage Scrub for coastal plain area of southern California, it is not surprising that it is a threatened community. It was formerly widespread from the coastal bluffs to the foothills but has been replaced throughout most of the region by urbanization, grazing, and agriculture.

Lower, or Warm Chaparral, is commonly found in foothill areas above the Coastal Sage Scrub. The occurrence of frost is a factor which separates this community from Coastal Sage Scrub. Also, summer fog is less common, while winter rain is somewhat higher. The upper limit of Warm Chaparral is probably related to the frequency of snowfall. Typical elevation ranges are from 1000 feet (300 m) to 5000 feet (1600 m). In contrast to the drought-deciduous plants of the Coastal Sage Scrub, most chaparral plants are evergreen. They have small waxy leaves and woody stems, and they grow much larger than plants of Coastal Sage Scrub. A mature stand of Warm Chaparral can be 10 feet high and nearly impossible to walk through, making the term "hard" Chaparral well-deserved. The most abundant Warm Chaparral plant is chamise, *Adenostoma fasciculatum*, which is particularly dominant on south-facing slopes. The other major shrub on south-facing slopes is California lilac, *Ceanothus* spp. On north-facing slopes the dominant shrubs include California scrub oak, *Quercus berberidifolia*, holly-leaved cherry, *Prunus ilicifolia*, and California coffeeberry, *Rhamnus californica*. These shrubs generally have larger leaves than the dominants on south-facing slopes.

Warm Chaparral is the scrub community most likely to burn. Wildfires have always been an important part of the environment, and most chaparral plants have evolved mechanisms for regenerating after burns. Common adaptations include the ability to sprout from roots ,seeds which require intense heat to germinate, and thick, fire-resistant bark. Since the foothills and lower mountain slopes dominated by Warm Chaparral are also some of the most desirable areas for upscale residential development, this natural tendency has led to a considerable amount of property damage and some loss of life. There is a lively controversy about the character of pre-20th Century fire regimes and the impacts of fire suppression during the modern period. Some believe that the natural regime was characterized by small, low-intensity fires which would only burn older Chaparral stands, leaving a mosaic of patches of differing ages. According to this theory, suppression has produced large patches of uniform old age

growth with substantial accumulations of dead wood and other fuels. This in turn has tended to encourage the spread of large conflagration fires during periods of hot, dry Santa Ana winds. Others believe that large, infrequent fires were characteristic of pre-suppression fire regimes, noting that Santa Ana winds will always tend to encourage fire storms, even in relatively young Chaparral stands, and that lightning-started fires are relatively rare in the western Transverse Ranges and southern Coast Ranges. Evidence from charcoal deposited on the floor of the Santa Barbara Channel suggests that large fires have been typical in the Santa Ynez Mountains for at least the last 1000 years.

Above about 4000-5000 feet (1200-1600 m), snow becomes a common element of climate, and the Cold Chaparral community takes over on south-facing slopes. This community is dominated by several different species of manzanita, *Arctostaphylos* spp. On north-facing slopes drought-adapted conifers dominate, especially Coulter pine, *Pinus coulteri*, and big-cone Douglas fir, *Pseudotsuga macrocarpa*. The latter species has turned out to be very useful as a recorder of past moisture fluctuations. Researchers in the UCSB Geography Department have produced dendrochronological reconstructions from sites in Santa Barbara and Ventura Counties that provide year-by-year records of winter precipitation variability extending back 500-600 years. These reconstructions indicate that interannual precipitation variability has been large, but there have been no long-term changes in average precipitation.

Yellow Pine Forest covers the highest peaks in the area, usually becoming dominant above 6000-7000 feet (1800-2100 m). Jeffrey pine, *Pinus jeffreyi*, is the most common conifer, with ponderosa pine, *Pinus ponderosa*, also present. Black oak, *Quercus kelloggii*, is the main deciduous species. Much of the winter precipitation in the Yellow Pine Forest falls as snow, and the trees of the community are adapted to a summer growing season, making them dependent on groundwater remaining from winter precipitation.

In relatively moist, low elevation hill and valley areas, Oak Woodland is the main vegetation community. It is usually dominated by one of the large oaks, such as coast live oak, *Quercus agrifolia*. This woodland, or savanna, landscape is in many ways the quintessential idealized central and southern California country landscape. The oaks are drought adapted with large spreading root systems, and attempts to incorporate them into urban developments have met with limited success. The biggest problems are fill soils, covering the extensive root system with concrete, or planting grass and ornamental plants requiring summer irrigation. This promotes the growth of a fungus that attacks the roots of the oaks and kills them.

One plant often found in association with Coast Live Oak and throughout the canyons and moister Chaparral-covered slopes of southern California is poison oak, *Taxicodendron (Rhus) diversiloba*. People who are allergic to it can develop severe rashes from contact with any portion of the plant. It is very attractive in autumn when its leaves turn bright red before falling, but the lack of leaves during winter can be particularly hazardous since it is much more difficult to identify and avoid.

Riparian Woodlands provide unique and distinctive environments contrasting strongly with the open scrub-covered slopes. Many of the riparian tree species are winter-deciduous, and they provide fine displays of fall color which belie the common misconception about seasonal displays held by people from the east. At the lower elevations the dominant trees are western sycamore, *Platanus racemosa*, and various willow species, *Salix* spp. white alder, *Alnus rhombifolia*, and big-leaf maple, *Acer macrophyllum* are common at intermediate elevations. Two evergreens, California bay, *Umbellularia californica*, and Pacific madrone, *Arbutus menziesii*, reach the southern extents of their ranges in cooler, north-facing slopes and canyons of the southern California mountains.

In addition to the complex climatic and topographic controls on vegetation, central California's geologic history has produced some unique edaphic plant communities associated with particular soil types. Probably the most noteworthy are the communities found on serpentine soils which extend from northern Santa Barbara County northward through the interior Coast Ranges. These soils tend to be drought-prone, but, possibly more importantly, they have relatively high concentrations of metals such as nickel and chromium which most plants have difficulty tolerating. As a result, plant communities tend to be very different from those on other soils in surrounding areas, often with relatively few species and less continuous cover. An additional factor contributing to the latter

may be the fact that the clay soils that often form on serpentine are unstable and prone to sliding on slopes.

Summary

This has been a quick introduction to the factors which make the physical environment of central and southern California so unique. Complex interactions between geology, climate, and vegetation have worked rapidly to produce the strikingly diverse environments of the area. The pace of change in the natural world has been, and continues to be, fast. In this century, the pace of change has been accelerated greatly, however, by human activity.

The appealing physical environment and Mediterranean climate have contributed significantly to the tremendous population growth that has transformed the area in the last several decades. Inevitably, the very qualities which attracted immigrants have come under siege. Plants and animals have suffered from significant loss of habitat. Air pollution has had demonstrable adverse effects on vegetation throughout southern California. The California Condor no longer exists in the wild. Coastal Sage Scrub is nearly gone, as are some of the animals which inhabit it.

On the other hand, there are still substantial areas that have not been overdeveloped where the impacts of modern society, while not absent, are not overwhelming either. Much has been lost, but much remains, providing hope and a challenge for future generations to do a better job of maintaining the beauty and of living with the hazards of the natural environment.

A Brief Guide to the Geology of Santa Barbara, California

by
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Santa Barbara's geographic setting makes it a popular vacation destination. The beauty of the Pacific Ocean, Channel Islands, and Santa Ynez Mountains all contribute to the aesthetic appeal of the area. If you have time to explore the area more closely, perhaps by taking a stroll on the beach or hiking in the mountains, you will get a chance to have a look at the geologic framework that underlies the area. A brief description of the geology of Santa Barbara follows.

Most of the area is underlain by rocks of the **Franciscan Formation**. In this area, the Franciscan rocks are Jurassic to Cretaceous in age and are comprised mainly of deep-water sedimentary rocks deposited on the ocean floor. During subduction, not all rocks descend neatly into the trench; rather, some get scraped up, deformed, and attached to the edge of the continent, forming what is known as an *accretionary wedge*. The Franciscan Formation represents the accretionary wedge formed during subduction of the Farallon plate beneath the North American plate.

The Franciscan assemblage is highly mixed and contains chert, greywacke sandstones, altered basalt, and serpentine. You won't see much of the Franciscan if you don't leave town, but, if you get a chance to visit Knapp's Castle (situated atop the ridge of the Santa Ynez Mountains off East Camino Cielo Road), you'll not only get a breathtaking view but also catch a glimpse of the Franciscan Formation – it's the greenish rock visible in the distance. In fact, looking out over the valley below Knapp's Castle, you are looking across the suture between the western Transverse Ranges block and the Coast Ranges block to the north. The Santa Ynez fault, which runs through the riverbed below you, is the boundary between the two blocks. If you don't make it to Knapp's Castle, you can also see the Franciscan just a bit north of the city on Highway 1.

The majority of the Santa Ynez Mountains are comprised of Eocene rocks. In fact, the Eocene section comprises over 3000 meters of rock. The Eocene formations include the **Juncal**, **Matilija**, **Cozy Dell**, and **Coldwater** formations. The Juncal, Matilija, and Cozy Dell formations were deposited in deep ocean water on the continental shelf as submarine fans, while the Coldwater Formation represents nearshore conditions, likely indicating the start of a withdrawal of the sea from the area. The Juncal and Cozy Dell formations are comprised mainly of relatively weak shale, while the Matilija and Coldwater formations are comprised mainly of resistant sandstone. Oyster beds may be found locally at the top of the Coldwater Formation. Looking at the mountains from below, the high peaks are formed by Matilija and Coldwater rocks, while low valleys are comprised of shale of the Juncal and/or Cozy Dell formations.

The sea made a full withdrawal from the area during the Oligocene, leaving a broad coastal plain. During this time the conglomerates, sandstones, and silts of the **Sespe Formation** were deposited. The Sespe is coarsest at the bottom and gets finer as you move up through the section. There are two possible explanations for the withdrawal of the sea and deposition of terrestrial rocks during this time period – eustatic drop in sea level or local uplift of the land - or possibly both. In any case, it is clear that the Sespe rocks are non-marine in origin. Their red color, visible in the mountainside when viewed from town, indicates oxidation of iron in the sediment, and sedimentary structures all suggest a flood-plain environment. There are no marine fossils in the Sespe, but land animal fossils are found in many locations. The rocks of the Sespe are also a great place to look for sedimentary structures. Cross-beds, channel cut and fills, graded beds, and other fluvial features can be found in abundance.

As relative sea level rose once more, the Miocene began with the deposition of the relatively thin layer of **Vaqueros Formation**, a buff colored sandstone unit, followed by deposition of a series of shales including the **Rincon Formation.** The Mission Ridge, a linear fold at the foot of the Santa Ynez Mountains, is comprised in part by the

Rincon Formation. The Rincon is a gray clay shale in which landslides and mudflows are common. The Rincon may not be a great formation on which to build your home for another reason: it is known as a source of radon.

If you get a chance to take a walk on the beach, you may notice the strong smell of tar on the breeze from time to time. You may also notice globs of tar on the beach (or on your feet after your walk!), or see "rocks" that on closer inspection are really just shells and sand stuck together with tar. This is because Santa Barbara is home to natural hydrocarbon seeps located just offshore from the UCSB campus. Often a nuisance to surfers and bathers, the natural oil seepage has attracted companies interested in offshore oil and gas exploration, making the Santa Barbara area one of the most important oil producing regions in California. The majority of this oil comes from the Miocene **Monterey Formation**, which lies above the Rincon Formation and stretches over a large portion of California. Not only rich in oil, the Monterey is also rich in marine fossils, preserving everything from whales and dolphins to kelp fossils seldom found elsewhere. If you visit Ellwood beach, you can view the Monterey Formation, which makes up the seacliff in this area. In fact, you can see an exposure of the More Ranch fault deforming the Monterey Formation in this area.

The **Sisquoc Formation**, lying above the Monterey, is a light gray siliceous silty shale rich in diatoms. If you walk along the shore from Goleta Beach to the UCSB campus, you'll see the Sisquoc exposed in the seacliff in this area. The Sisquoc acts as a cap rock to trap oil and gas from the Monterey Formation. However, fractures in the Sisquoc along the axis of offshore anticlines allow the oil and gas to migrate through; hence the tar along our beaches.

The Plio-Pleistocene **Santa Barbara Formation**, which lies over the Miocene formations, is a transgressive marine sandstone containing minor units of siltstone and claystone. The formation is poorly understood, having been dated at younger than 1.2 million years based on the presence of the Bailey Ash found beneath it (Izett et al, 1974). Gurrola and Keller (pers. communication) have dated the Santa Barbara formation at younger than 790 thousand years based on paleomagnetic analysis. The Santa Barbara Formation can be seen atop the Mesa hills downtown.

The mainly non-marine **Casitas Formation** overlies the Santa Barbara Formation. It is comprised of pebbly sandstone and cobble-gravel conglomerate with minor units of silt and clay. The non-marine character of the Casitas results from alluvial deposition on the coastal piedmont as uplift and sea level regression occurred. The Casitas Formation is exposed in the Ortega Hill anticline near Summerland, east of Santa Barbara.

The Santa Barbara and Casitas formations are overlain by late Pleistocene to Holocene alluvium and fanglomerate deposits, the young sediments covering the coastal piedmont. You can see some of these deposits if you walk along the beach; you'll notice that the rock of the seacliff abruptly ends about 2/3 of the way up where sediment deposits begin.

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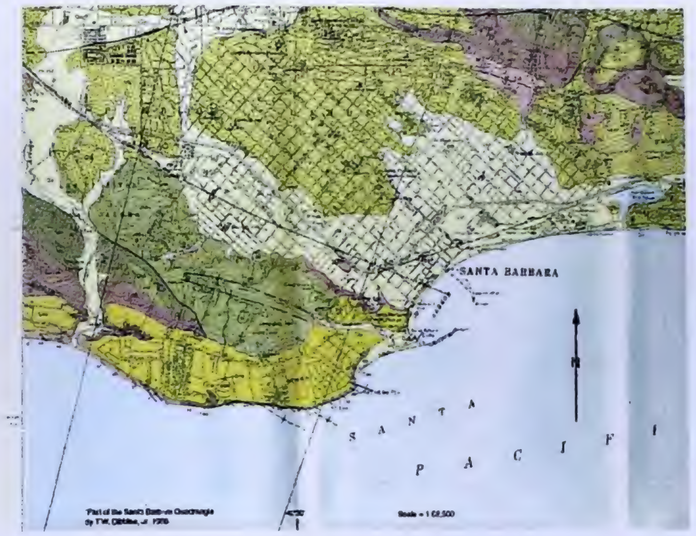
Geologic maps from:

Dibblee, T.W. Jr. (1966) Geology of the Central Santa Ynez Mountains, Santa Barbara County, California, California Division of Mines and Geology, Bulletin 186, 99p.

Figure 1a: Geologic Map of Santa Barbara



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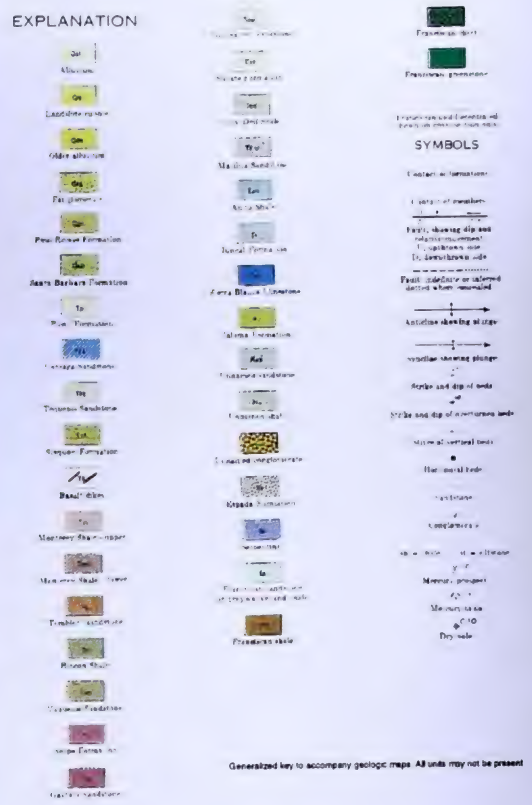
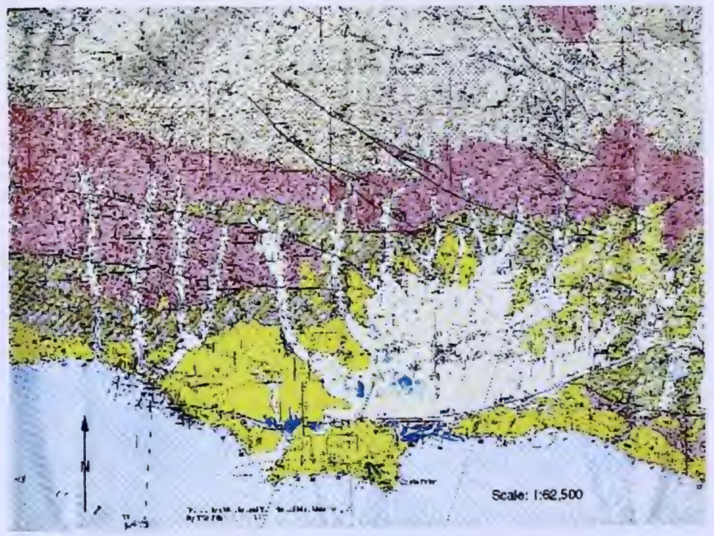


Figure 1b: Geologic Map of UCSB



Tectonics of Santa Barbara, California

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Gazing out at the Channel Islands on a clear day in Santa Barbara, you may find yourself imagining the distant lands that lie beyond. Hawaii, Japan, and China probably come to mind. In reality, if you got into a boat, put the coastline directly behind you, and set sail away from the land, you would be waiting a long time to make landfall. When you finally did, you'd be in Antarctica! Unlike most of California, Santa Barbara has a south-facing coastline, explaining why it is difficult to see the sun set directly over the ocean here.

Nestled between the Santa Ynez Mountains to the north and the Pacific Ocean to the south, Santa Barbara occupies a relatively narrow stretch of coastal plain. This fortuitous geographic setting allows you to visit the beach in the morning and be hiking in the mountains by noon. On most days you can see some of the Channel Islands, including (from west to east) Santa Rosa, Santa Cruz, and Anacapa Islands. On a really clear day you may catch a glimpse of San Miguel Island and even make out topography on Santa Cruz Island, the largest of the Channel Islands. The panoramic view of these islands is part of what makes the Santa Barbara coastline unique. The orientation of Santa Barbara's coastline, in addition to the origin of the Channel Islands and Santa Ynez Mountains, is a result of the complex tectonic history of the area.

The Santa Ynez Mountains form the northern border of the greater Santa Barbara area. They are part of the western Transverse Ranges, a series of east-west trending mountain ranges spanning from the Santa Barbara area east to Los Angeles. The western Transverse Ranges break up the north-south structural grain of the rest of California, due largely in part to the "Big Bend" in the San Andreas fault. The San Andreas fault runs roughly north-south in much of California; however, in the vicinity of the Big Bend, it turns and runs approximately east-west (Figure 1). This complicates the right-lateral strike-slip motion of the fault, and causes compression and shortening of the crust in that region. The faults and folds that comprise the western Transverse Ranges are the result of this compression. For most "Santa Barbarans," having the mountains to the north and ocean to the south is quite normal – we're used to this orientation. Our little piece of land, however, was not always oriented this way. In fact, what is now the Santa Barbara area didn't even start out at its present latitude!

Figure 1: Location of Santa Barbara and the Big Bend of the San Andreas Fault

It is believed that, during the Mesozoic and early Cenozoic, the crustal block that contains the western Transverse Ranges was oriented north-south, roughly perpendicular to its present orientation. The Channel Islands, now the southern edge of the block, probably lay near San Diego. During this time, the tectonic regime of the area was quite different than it is today, and a subduction zone occupied the region. The Farallon plate was being subducted beneath the North American plate, and the western Transverse Ranges block lay in the forearc region of this subduction zone. It is during this time that some of the deep-water formations of the area were deposited (see geology information below). This regime was more or less stable until the mid-Cenozoic, when a spreading center, the boundary between the Farallon and Pacific plates, approached the trench. The collision of the spreading center with the continent was partially responsible for uplift that may be represented by the terrestrial Sespe Formation (see geology information below) (Atwater, 1998). When the Pacific plate made contact with the North American plate, about 27 million years ago, some continental pieces broke off and joined the Pacific Plate. At this time the subduction zone between the Farallon and North American plates ceased to exist and the new transform margin began to form, setting up the beginnings of the San Andreas fault system. This is where it gets interesting.

Paleomagnetic data indicate that the western Transverse Ranges block, among others, has rotated clockwise at various times during the Neogene (Luyendyk, 2001). The western Transverse Ranges block was one of three north-south blocks that broke off the rim of North America during the early Miocene. The other two blocks became attached to the Pacific plate; however, the northern edge of the western Transverse Ranges block got "stuck" in the continent while the southern end broke away and swung out and northward (Atwater, 1998). As the block rotated, igneous and metamorphic rocks rose to fill the space left to the east of the block. This space is now occupied in part by the Los Angeles Basin. It is likely that net clockwise rotation of the western Transverse Ranges block may be as much as 100 degrees, giving an average rotation rate of about 5-6 degrees per million years (Luyendyk, 2001). The rotation model helps explain some of the complex geology in the area. For example, extension related to the rotation is responsible for the uplift and exposure of the Catalina schist, recorded by the San Onofre breccia, which contains rocks from the Catalina schist. Also, the deep, isolated basins formed during this time provided the environment required for the deposition of the Monterey Formation (see Geology information below) (Atwater, 1998).

For most of the Miocene, during the rotation of the western Transverse Ranges block, southern California was the site of the southern, oblique transtensional portion of the boundary between the Pacific and North American plates (Atwater, 1998). Between 19 and 12 million years ago, the boundary grew as the northern end (Mendocino triple junction) was migrating up the coast with the Pacific Plate, while the southern end of the boundary (Rivera triple junction) remained more or less stable off northern Baja California. At about 12 million years ago, subduction and spreading off southern Baja stalled and the Rivera triple junction was transferred far to the south (Atwater, 1998). However, because the plate boundary was still on the Pacific side of Baja, this did not immediately affect the tectonic regime of southern California.

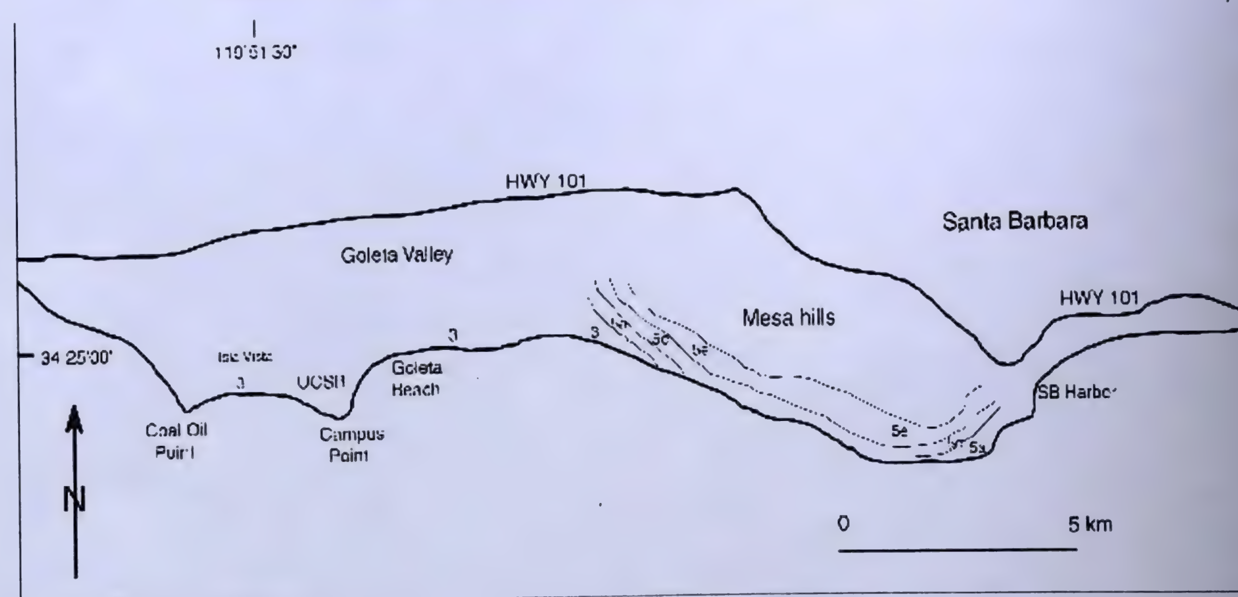
About 5 million years ago, the Pacific plate captured Baja California, drastically changing the tectonic regime of the area. This shifted the Pacific-North American plate boundary from the coast to within the Gulf of California, causing the boundary to shift within southern California to connect to this new location. At this time, the present southern California segments of the San Andreas fault, including the Big Bend, were formed (Atwater, 1998). This new tectonic regime caused the western Transverse Ranges Block to become snagged yet again, this time at its eastern end. This brings us to the present tectonic regime.

Since about 5 million years ago, the western Transverse Ranges have been experiencing north-south crustal shortening and being extruded west around the Big Bend. In response to this new tectonic regime, parallel to subparallel (predominantly) left-slip strike-slip faults have formed along the southern edge of the western Transverse Ranges block. Furthermore, various normal faults formed during Miocene extension have been reactivated as reverse faults (Atwater, 1998). Another effect of the shortening and extrusion is that major folds and faults on the south side of the San Andreas tend to propagate to the west, while folds and faults north of the San Andreas tend to propagate to the east (Gurrola et al., 1998). Keller, et al. (1997) suggest that this pattern of propagation may be reflected by rupture during earthquakes in the region. Although this hypothesis is speculative, data from historic

earthquakes seems to support westward propagation south of the San Andreas and eastward propagation north of the San Andreas (Gurrola et al., 1998). Earthquake damage is usually most severe in the direction of propagating rupture, so this hypothesis has important ramifications for earthquake hazard analysis. If we can predict the direction of propagation of rupture during an earthquake, we can better model potential damages to structures.

Santa Barbara is very active tectonically, and is characterized by faulting, folding and uplift. Historic seismicity in the area has been significant, and the 1925 magnitude 6.3 quake caused severe damage to the downtown. Nearly 200,000 people live in the Santa Barbara area, and the threat posed by the active folding and faulting in the region is still largely unknown. Better resolution of the earthquake hazard is imperative in this region with its high rate of deformation. Determination of uplift rates is important to earthquake hazard assessment and aids in understanding seismically active areas. Provided the chronology can be resolved, marine terraces offer an opportunity to determine uplift rates. Marine terraces are abundant in the Santa Barbara area, preserved on the flanks of actively growing folds. In fact, if you are on the UCSB campus, you're sitting atop a marine terrace right now. Uranium-series dating of corals found in marine terrace deposits is commonly used to determine the age of a particular terrace. Unfortunately, corals are rare in terrace deposits, and many terraces are of unknown age. Several methods of correlating undated terraces to those with U-series dates have been developed, including amino-acid racemization, ^{14}C dating (of terraces younger than 50,000 years old only), paleontological correlations, and oxygen isotope stratigraphy. Geologists at UCSB have had some success using oxygen isotope stratigraphy to assign ages to and calculate uplift rates for Santa Barbara area marine terraces (Figure 2) (Trecker et al., 1998). U-series dated terraces in Isla Vista and at Santa Barbara City College provided calibration points to which isotopic data from Santa Barbara Point and Punta Gorda (near Ventura) were compared. Using the oxygen isotopic data coupled with the U-series dates and geomorphic analysis, they calculate uplift rates ranging from 0.62 +/- 0.03 mm/yr to 0.54 +/- 0.05 mm/yr for marine terraces preserved on the Mesa hills anticline located in downtown Santa Barbara. Resolution of the uplift rate in this area is important, because the Mesa hills anticline is young and potentially active. The range of uplift rates reflects different rates and styles of deformation along the Mesa hills structures. Interestingly, the uplift rates recorded in the Mesa hills are significantly lower than the rate of 1.22 +/- 0.13 mm/yr calculated by Gurrola, et al. (1996) at Isla Vista, only 10 km away. This large difference in uplift rates over a short geographical distance illustrates not only the complexity of Santa Barbara's tectonic regime, but also the utility of oxygen isotope correlations in providing a means for improving the record of uplift rates in an area (Fig. 2).

Figure 2: Location of Marine Terraces and the Mesa Hills.



(Numbers refer to oxygen isotope stages, corresponding ages are approximate: 3a = 40-60 ka, 5a = 70ka, 5c = 85 ka, 5e = 125 ka. Modified from Gurroa et. al. 1998)

Assessing Landslide Hazard Over a 130-Year Period for La Conchita, California

by
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Abstract

A landslide consisting of 600,000 tons of mud and silt slid 600 feet down a cliff face and buried nine homes in La Conchita, California on March 4, 1995. The landslide history of this area was considered in the ensuing litigation, which centered on the ranch above the failed slope and whether or not a direct causal link between irrigation and the slope failure could be made. Residents of La Conchita attributed the cause of the landslide to excessive irrigation by the ranch owners. Important for this investigation were the analysis of the naturally unstable geological setting, the unique hydrologic environment of the tectonically elevated bluffs, and unusually high rainfall brought about by El Nino. Establishing the history of landslides in the area relied on historical zoning maps, written accounts of landslides, historic air photo interpretation, digital elevation models, geologic information, and hydrologic analysis.

Introduction

La Conchita is a small coastal town located in Ventura County, California next to the 101 Freeway, approximately 50 miles southeast of Santa Barbara, just down the coast from the town of Carpinteria near Rincon Point (See Figure 1, Location Map, at the end of the paper). The rugged and eroded appearance of the cliffs above the town has a marked difference to that of other coastal sections of the 101 Freeway. The town itself is covers 28 acres and is situated on a gently sloping elevated marine terrace that is about 20-100 feet above sea level and today has approximately 150 structures (SMC, 1996). The southwestern most part of the town is 19 feet above sea level, and the highest point in the town is 120 feet above sea level in the vicinity of the toe of the 1995 slide. The higher average elevation in this area is due to the build-up of mudflow debris that has accumulated along the base of the cliff. The La Conchita Ranch extends inland from the 500-600 foot high cliffs above the town for about a half a mile. The highest point on the ranch property is about 1,400 feet above sea level at the base of Red Mountain. The ranch consists of more than 680 acres, of which approximately 415 acres are avocado and citrus trees. These trees were planted some time after 1974 when the land use of the ranch property changed from grazing and dry farming to irrigated agriculture.

A noticeable feature when driving past La Conchita on the 101 Freeway is the Rincon Oil Field and the offshore drilling facility, called Rincon Island, that extends about half a mile out from Punta Gorda point. Oil and natural gas were discovered there in 1927 in Pliocene age strata about 3000 feet below sea level (Sylvester, 1986). Around 1960, Rincon Island started operation, and to date more than 150 million barrels have been extracted (Sylvester, 1986). The tectonic pressures exerted by active faults are responsible for the existence of the oil and natural gas near the surface in this area and in the Santa Barbara Channel. The Ventura Avenue Anticline and the Red Mountain Thrust Fault, as well as numerous smaller faults, have significantly influenced the topography of this area.

Landslide History

Beginning as far back as the late 1800s there are records of landslides in the La Conchita area. In essays written by a resident that are nearly a century old, there is reference to debris flows covering cultivated lands and damage to structures caused by mass wasting events. The following material summarizes important historical landslide events researched as part of the legal investigation by one Kristing Coddington and documented in a chronology spanning 1865 to 1958 (Coddington, 1998). In 1865, there was a wagon trail through this section of coastline that connected Santa Barbara and Ventura which a surveyor described as follows: "the character of this road was so changeable in consequence of the falling down of masses of earth from the cliffs, which in some places were 400

feet high, and from the washing of the earth by the waves, that the road for the transportation of goods was nearly worthless." Southern Pacific Railroad laid tracks through La Conchita in 1887; two years later in 1889 sections of the tracks were buried by the first of two landslides. In December 1889, the Ventura Free Press reports that, "West of Ventura somewhere on the cliffs there is a dead engine stalled in the landslides..." The January 29, 1909 edition of the Santa Barbara Independent reported on the Punta Gorda slide, and, as a consequence of this slide, changes to the rail and the section of road running through La Conchita were made. The author of this article described the stability of the area surrounding La Conchita by saying: "The character of the soil of the mountain, which rises almost abruptly from the sea, is such that there can be no security from slides, such as the avalanche of dirt and rocks that last Saturday swept down on the road and buried a work train." As a result of this slide, Southern Pacific Railroad had to excavate several railroad cars, and major plans for construction of a causeway and the reinforcement of the railroad began. In an effort to reduce the hazard imposed by the steep cliff face, Southern Pacific Railroad bulldozed flat the area adjacent to the railroad which facilitated the development of the area and the eventual construction of houses. In 1924 the La Conchita del Mar subdivision was established. It consisted of approximately 330 lots and another 47 lots in a row up against the base of the cliff (SMC, 1996). A zoning map drawn in the early 1930's shows that most of the land in the town of La Conchita was agricultural and, according to the legend on the drawing, the lowest value parcels were actually composed of mudflow debris.

Geologic History

Geologic evidence suggests that the 1995 landslide, and other landslide events along this section of coastline, are a relatively frequent occurrence. The distinguished geologist, William C. Putnam, described the geology of this area in detail in a report authored for the Geologic Society of America in 1942. The report points out numerous signs that there have been significant changes to the topography of this area in geologically recent times. For example, the exposed strata visible on the cliff face and in areas on top of the bluffs contain shells of species that established themselves in warmer postglacial times (Putnam, 1942). Marine sediments, mollusk shells, and sandstone boulders with bore holes and barnacles can be found in various locations in this area (Putnam, 1942; Sylvester, 1988; Harden, 1986). There are eight or nine distinct scarps where the different uplifted wave cut platforms are visible near the surface (Sylvester, 88; Harden, 1987). The Punta Gorda marine terrace is about 1300 feet above sea level in the middle of the La Conchita ranch, and it is estimated to have been at or near sea level between 40,000 and 60,000 year ago. Located nearby is a fluvial terrace that was dated using charcoal deposits and determined to be as young as 2000 years old (Harden, 1987). Based on a detailed analysis of soil samples, it is estimated that uplifting rates are about 4.2 – 5 meters per 1000 years. In terms of tectonic uplifting, this is one of the fastest in the world (Sylvester, 1988).

Two drainages border the La Conchita ranch, the Padre San Juan and Javon Canyons, and both are deeply incised and have steep eroding walls. Putnam (1942) noted the young, but abnormally deep, well-developed drainage pattern in this area as being a result of tectonic uplifting. He also noted the presence of gravel benches in the canyon walls that developed during episodes of canyon cutting followed by filling in the recent geologic past. Putnam attributed the deep canyon cutting and filling episodes to two possible causes, climatic fluctuations that caused changes in the amount of winter runoff and tectonic uplifting. As far as landslides are concerned, Putnam (1942) states that, "Nearly every square foot of surface on the hill slopes underlain by upper Pico clay shale is in motion down slope or has moved in the very recent geologic past." Given the geologic composition and the tectonic origins of cliffs above La Conchita, it is difficult to understand how development was allowed in the area at the base of the cliffs, given the high risk of landslides.

Geologic stability of subsurface soil layers and the slope of the hillside are important considerations for landslide risk assessment. Also important are the hydrologic environment and proximity to active faults. One influential feature in this area is the Red Mountain Thrust Fault that runs from the Ventura River to the east, around the Red Mountain Dome above the La Conchita Ranch, and off shore near Rincon Point up the coast to the west of La Conchita. This fault has exerted significant influence on the drainage pattern visible around the study area; differential erosion rates of resistant Miocene age strata over weak clay and shale has caused the canyons bordering the ranch above La Conchita to become deeply incised in some areas and restricted in others (Putnam 1942). The canyons are confined where they cross the resistant rock layers upturned by the Red Mountain Fault, and the canyons

are deep where they traverse weaker clay and shale layers.

Discussion

Seventy-one homeowners sued La Conchita Ranch Co. in *Bateman v. La Conchita Ranch Co.* The premise of the case brought against the ranch owners was that irrigation was the cause of the 1995 landslide, because irrigation has the tendency to raise the water table and potentially cause weakness in hill slopes. In the area around the toe of the slide, water emanates from beneath the cliffs on a seasonal cycle. This is a sign that the heterogeneous mix of slide debris that forms the base of the cliff is draining, and the pore pressure within the toe of the slide is being maintained at a relatively constant level. In light of extenuating environmental and geological circumstances, irrigation cannot be assigned as the direct cause of the slide. The presence of excess groundwater from intense precipitation reduced the cohesion between the soil layers by rapidly increasing the pore pressure, which initiated the landslide. In January 1995 over 18 inches of rain fell, resulting in the wettest January ever recorded in this area, and one local rain gauge recorded 1.6 inches of rain in a one half hour period in Santa Barbara. This unusually high precipitation was also noted in a Santa Barbara News Press article titled "La Conchita residents lose $24 million landslide suit" written by Chuck Schultz on January 16, 1999. The article reports that home values in the area surrounding the toe of the slide, and in the vicinity, have decreased significantly as a result of the landslide hazard.

Ranch personnel reported the first observed visible evidence that the hillside was getting ready to break loose in 1994; a series of longitudinal cracks had developed in an asphalt road above the ravine where the landslide occurred (SMC, 1996). Devices installed in bore holes of various depths in the toe of the slide recorded slight movements and changes in ground water content within the toe of the slide until January afternoon in 1995 when the first segment of the landslide broke loose and accelerated down slope (SMC, 1996). This first segment did not reach the town, but within 20 minutes two more segments broke loose along the aforementioned cracks and accelerated down slope as a coherent mass of mud and debris. There were two other slide events leading up to the big one in 1995—one occurred in 1988 and another in 1991. These two smaller debris slides did not have sufficient mass to accelerate down slope and were stopped by the ranch road. After both of these smaller slides, the road was cleared and improved, but, after the 1995 slide, the road was gone.

Vegetation on hill slopes is commonly believed to help prevent landslides, but this is only partially true (Campbell, 1975). The cliffs above La Conchita are covered with a dense carpet of coastal sage shrub and some scattered trees. Pockets of phreatophytes and ivy grow in areas where there are natural springs. This vegetation cover may in fact increase the risk of landslides, because their characteristically thick humus layer increases the amount of rainfall that can infiltrate the surface by reducing the potential for direct runoff. Although vegetation cover does reduce grain-by-grain erosion caused by flowing water, a thick layer of decaying leaves can facilitate rapid infiltration and a sudden spike in pore-water pressure that could have reduced the cohesion in the soil comprising the sides of the baranca that constituted the source material of the 1995 slide. In a 1975 Geological Survey Professional Paper authored by Russel H. Campbell, the correlation between heavy precipitation events and landslides in southern California's Santa Monica Mountains was explored. Aerial reconnaissance, official reports, and eye witness accounts were used to census landslides after two intense storm periods that occurred in November/December of 1965 and January/February of 1969, the later period being the focus of the report. The situation and location of soil slips and debris flows during this period were compared with rain gauge records, radar derived precipitation intensity maps, and soils maps. According to data on the timing of landslides and hourly precipitation totals gathered from various sources during these intense storm periods in 1965 and 1969, he found that intense rainfall, greater than 0.25 in/hr, was recorded at or near almost all of the major slide events recorded during the two major storm events. Special physical and environmental conditions in this area of Southern California, and other semiarid coastal mountainous climate zones, create an environment that is conducive to landslides of all types (Campbell, 1975).

A further consideration in assessing the La Conchita landslide is the fact that the ranch itself is isolated on a mesa, blocked essentially on all sides from any groundwater recharge. The only possible sources of groundwater are precipitation and irrigation. Although it is possible that the irrigation water could have percolated to a limited extent into the groundwater, it is unlikely to be the cause of the landslide. During winter, when there is an abundance of

rainfall, irrigation is not necessary. Moisture from groundwater is essentially sucked out of the upper layers of the soil by evapotranspiration during the hot summer months when irrigation is necessary to sustain the more than 400 acres of Lemon and Avocado trees.

Excess water from precipitation that does infiltrate through to the water table drains along the path of least resistance and follows the force of gravity; the faults that exit through the cliff face provide this path of least resistance. These faults, and their tell tale scarps, are visible in the aerial photography. There is an active fault that runs directly through the cliff face where the slide mass broke loose, and this could have potentially been the point of weakness that caused the landslide. The groundwater table within the elevated mesa can maintain a relatively constant level so long as the water entering the uppermost surface can be balanced by groundwater percolation, transmission though the soil layers, and eventual drainage out of springs in the canyon walls or out of the cliff face. The rainfall that causes landslides must be of sufficient duration and strength to raise the field capacity of the soil, the point where under gravity infiltration will equal percolation (Campbell, 1975). At this point, the soil layer will become saturated with additional infiltration. With an abrupt increase in infiltration that exceeds percolation, the pore-pressure between soil particles decreases, and the upper layers of soil become saturated. As water replaces air between the soil granules, the resistance of soil layers to shear stress decreases and the mass of the saturated soil breaks loose. From the analysis of the timing of several slope failures and precipitation totals during the 1969 study period, Campbell states that a minimum total of 10.5 inches of rain with a minimum threshold intensity of 0.25 in/hr was sufficient to induce sliding in most cases. Campbell points out that, in several instances during the "80 year storm" that occurred in January of 1969, catastrophic damaging slides occurred well before the total rainfall reached 10 inches. This, he postulated, supports the hypothesis that intense rainfall contributes to slope failure more so than a large total resulting from sustained light rainfall.

Conclusions

The investigation of the 1995 La Conchita landslide utilized several sources of historic information to evaluate the accusation that excessive irrigation by the bluff top ranch owners caused the landslide. Establishing the landslide history of the area relied upon historical aerial photography dating back to 1927 and DEMs (Figure 2, end of paper) constructed from the contours of a topographic map plotted in 1869, 1947 and 1995. Visual analysis confirmed that numerous alterations to the cliffs of La Conchita have occurred over the past 130 years. Extremely intense precipitation brought about by El Nino was also a contributing factor. Geologically speaking, this area is unique. The uplifted marine terraces that comprise the cliffs from which the slide originated and the accumulated slide debris upon which La Conchita is built further the contention that this landslide was a natural occurrence. The argument that this landslide could not be attributed directly to excessive irrigation had "the greater convincing force" in the words of the judge in this case, and, based on testimony from experts and evidence from historical sources and measurements taken by geotechincal professionals, it was the ruling by the judge that this case can never again be brought against the ranch owners, based on the premise that the irrigation caused the landslide.

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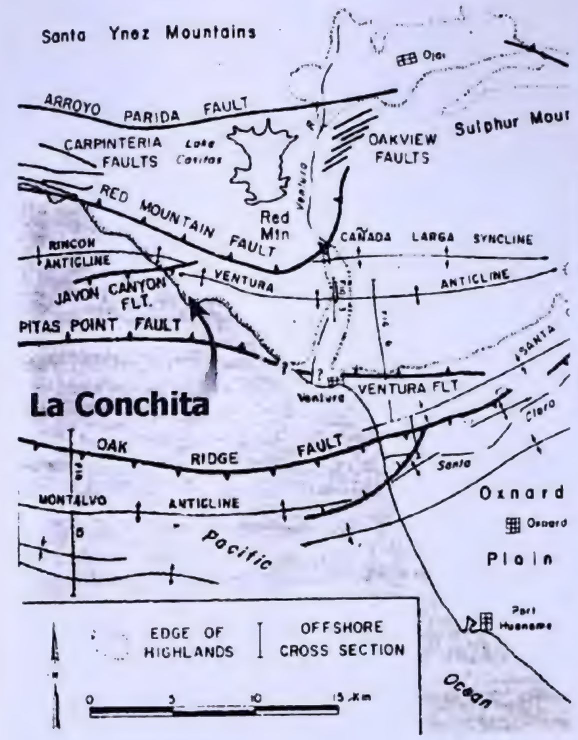
Figures

Figure 1: Location Map

Left:	**After Sylvester, 1988. Map Shows The Approximate Location Of The Town Of La Conchita And The Surrounding Faults.**
Right:	**2-9-98 Air Photo Showing La Conchita And The Escarpment Left By The 1955 Landslide.**



History Of Water In Santa Barbara, California

(Originally published in Pacifica Spring, 2001)

by
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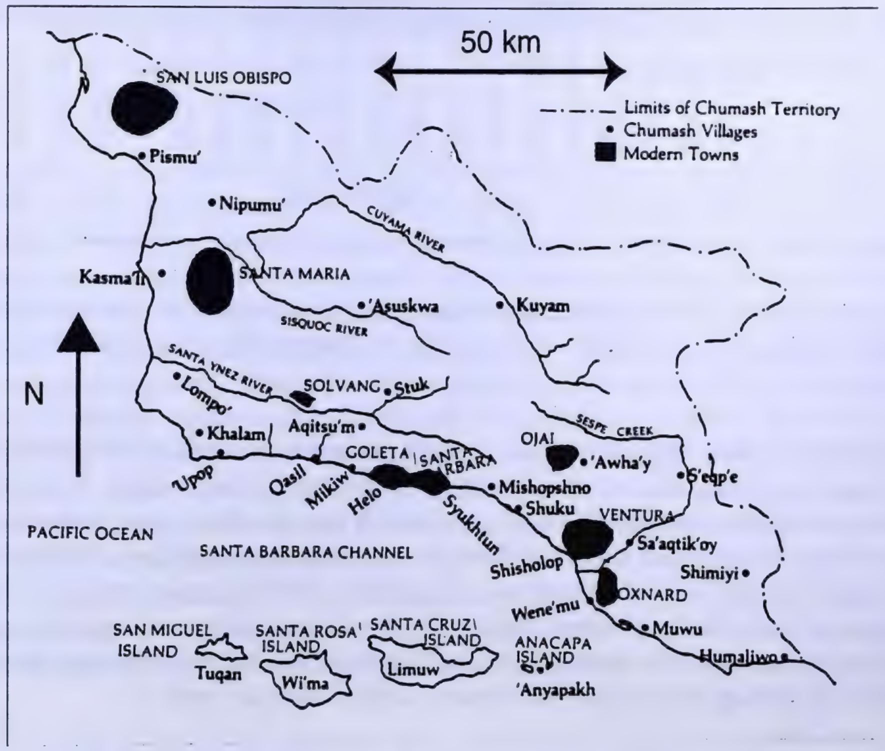
Introduction

The Chumash Indians were the first humans to utilize the water resources of the California region that currently encompasses the City of Santa Barbara. Prior to the 1542 visit of the Santa Barbara coastline by Spaniard Juan Rodriguez Cabrillo, the Chumash had dwelt for thousands of years in central and southern California. The Chumash territory extended from the Pacific coast to the inter-montane valleys. Its southern end was Malibu (or Humaliwoo, " the surf sounds loud" in Chumash dialect) in Los Angeles county, extended northward through Santa Barbara county, up to Morro Bay, a few kilometers north of Pismo or Pismu´ ("tar" in Chumash dialect) in San Luis Obispo County at its northern tip. A map of the Chumash territory is shown in Figure 1, where the locations and names of its largest villages are shown, along with the largest modern towns now in existence. The Chumash relied on springs, creeks, and rivers as their water source for drinking, cooking, bathing, cleaning, building artifacts and preparing other materials. The inland Chumash were primarily hunter-gatherers, while coastal Chumash relied on fishing as well for their subsistence. In addition, these geographically distinct Chumash groups traded goods, but neither one practiced agriculture.

Figure 1. Map of the Chumash territory



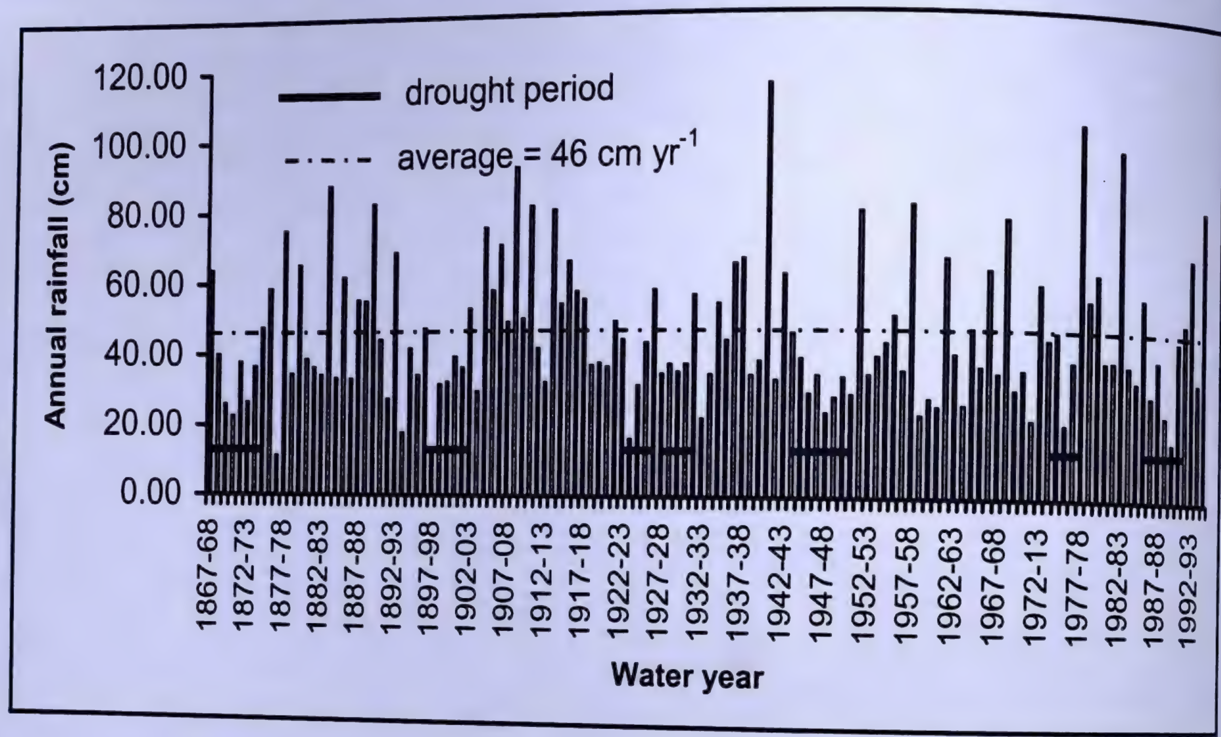
(adapted from Santa Barbara Museum of Natural History, 1996)

Pre-colonial life in the central and southern California coastal regions was, as it is today, subject to the vagaries of the climate. There, occasional drought periods lasting several years are interspersed with very wet winters, typically associated with strong El Niño years. Even years of normal precipitation (about 46 cm yr^{-1} in what is today downtown Santa Barbara) exhibit a seasonal drought cycle. Precipitation, essentially all as rainfall, falls almost entirely from November through April, the cool and wet season. Thereafter, commences a seasonal dry and warm period

that usually lasts through October. Thus, spring flow and flow in creeks and rivers is highly seasonal.

Many water sources dry up naturally during the summer and cease to flow for several years during multi-year droughts. Figure 2 shows a time series of annual rainfall in the City of Santa Barbara from water year 1867-68 (i.e., from October 1, 1867, through September 30, 1868) to water year 1994-95. Drought periods are identified in Figure 2 as sequences of four or more consecutive water years in which annual rainfall was less than the average annual of 46 cm yr^{-1} (see Loáiciga and Leipnik, 1996).

Figure 2. Annual rainfall in the City of Santa Barbara.



Droughts are periods of four or more consecutive water years with rainfall below the average annual rainfall (a water year spans from October 1 of any year to September 30 of the following year).

Figure 2 makes it evident that there have been seven droughts (as herein defined) in Santa Barbara in the last 130 years, or, on the average, approximately one every twenty years. In view of the recurrent threat of drought, it is not surprising that the largest Chumash settlements were correlated in a geographical sense with the location of reliable water. That pattern of human placement is still true today in the inland regions of Santa Barbara County, where major cities are located along the Santa Maria and Santa Ynez rivers, the two largest streams in that county. In the southern coastal region of Santa Barbara County, where the City of Santa Barbara and neighboring towns (Goleta, Carpinteria, Montecito, Summerland) lie, there are no large perennial streams. Nevertheless, the birthplace of cities such as Santa Barbara was tied up to small but vital streams such as Mission Creek.

During the Chumash era there were fairly good size springs that, combined with creek flow, could sustain enclaves of a few hundred people in that coastal region. There were numerous springs in the south facing slopes of the Santa Ynez Mountains of Santa Barbara County. Precipitation in the mountain tops infiltrated into fractured bedrock aquifers that discharged -unhindered by human exploits- through springs along the foothills and sustained the summer baseflow in several creeks found in Santa Barbara County's south coast. Carpinteria, Cold Springs, Mission, San Antonio, San Ysidro, San Jose, and San Roque are some of the largest creeks in the south coast of Santa Barbara County.

The Chumash most certainly engaged in primitive water development by enhancing the discharge zone of springs through excavation and ponding. They created small dams by piling rocks along stream beds. It is also probable that they dug shallow wells in the drier inner valleys, such as in the Cuyama River's valley, where the Kuyam ("to rest, to wait") village was located. One must realize that in pre-colonial times, in the absence of ground-water wells, irrigation, drainage, and diversion structures and with lands covered with drought-adapted vegetation, water tables were higher than they are today. This provided easier access to ground water. It also helped support flow in streams during dry periods at levels higher than in present times.

The waterscape in the south coast of Santa Barbara County has changed dramatically since the settlement of Santa Barbara in 1782 by Captain José Francisco Ortega and the establishment of the Santa Barbara Mission in 1786 by Father Fermín Francisco de Lasuén at the center of what would eventually become the City of Santa Barbara. Today, the City of Santa Barbara and neighboring towns house nearly a quarter of a million people. This is not an impressive number when compared with the millions of people who inhabit the Los Angeles basin in southern California. But it is a large population when one considers the scarce local fresh-water resources available to support it. Those local resources were adequate to support the Chumash inhabitants in the millennia preceding the European conquest, but fall short of the water needs of the 21st century. In the next sections we synthesize the post-1786 history of water resources in the City of Santa Barbara and its immediate environs in the south coast of Santa Barbara County, California.

Santa Barbara Water In The 19th Century

The genesis of the city of Santa Barbara began with the establishment of the 10th California mission 1786. Four other missions were created within Chumash territory between 1772 and 1804: San Buenaventura (in Ventura), Santa Ynez (in what is now the city of Solvang), La Purísima Concepción (near Lompoc), and San Luis Obispo. The missions were outposts with dual religious and military purposes. In addition to clerical personnel, a military contingent was stationed at the missions and presidios (i.e., literally prisons, but presidios were, in fact, garrisons) to protect Spain's political and military interests.

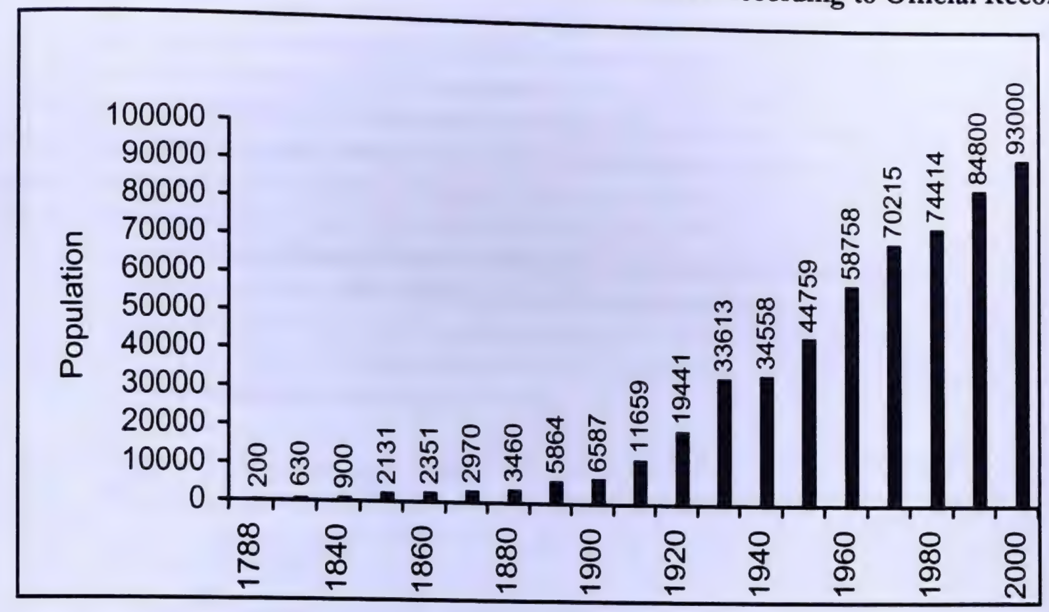
The Santa Barbara Mission was completed in 1820. The compound included a chapel, living quarters, stables, plots to grow crops, and corrals for the cattle and other animals. Indians came to the Mission from the surrounding environs, while others lived within the mission quarters. The Mission was the center of social activity in the Santa Barbara south coast in the colonial period. The earliest census in Santa Barbara dates from 1788, where it was reported that there were "200 whites and about 4000 Indians" living in the area (archives from the Santa Barbara Historical Society, personal communication, 2001). Water was an essential element to support the concentration of population in and around the growing village. The first colonial-era waterworks in the Santa Barbara region (i.e., in the south coast of Santa Barbara county outlined earlier) were undertaken to provide the Mission and Presidio with the water that they needed. That water came from hand-dug wells, springs, and from Mission Creek, where rudimentary dams were built to pond water and divert it via gravity flumes to small storage reservoirs near the places of water use. Indian Dam, completed in 1807 for the Mission, rose 4.6 meters above the bed of Mission Creek about one and one-half miles upstream from the Mission (see Figure 3). It was made of masonry and backed up water for about one 91 meters (Eckman, 1967). Based on reconnaissance studies of the area, the author estimates a storage capacity of about 13,000 cubic meters. Ruins of the dams and stone flumes that conveyed the water to the Mission can still be seen in Mission Creek and its tributary Rattlesnake Creek.

Figure 3: Map of Santa Barbara and historical water landmarks.

Water use is, and was in the Santa Barbara of the 19th century, a function of population and economic activity. The economy of that time was largely agrarian. Large ranches engulfed Santa Barbara, with cattle ranching being a primary land use. As far as population is concerned, information is sketchy. The decennial census mandated by the United States Constitution did not come into effect until 1850, when Santa Barbara had just become federal territory following the Mexican-American War. Spanish authorities conducted their own head counts, dating back to 1778, whose figures were quoted above. Figure 4 shows the population data for Santa Barbara from 1778 to 2000, which exhibit the typical "S" shape (or logistic) growth.

The data in Figure 4 deserve explanation. It was stated above that early head counts counted "white" and "non-white" people separately. Thus, the population figures for the 18th century and part of the 19th century shown in Figure 4 represent an undercount of the total population living in Santa Barbara. This is so because early census left out "non-white" individuals, and it excluded the Chumash people. [It is estimated that by 1920 the Chumash population had dwindled to 30 % of what is was in 1782].

Figure 4: Santa Barbara Population From 1788 to 2000 According to Official Records.



(see text for explanation; source: Santa Barbara Historical Society, 2001)

Accurate population counts are useful for estimating water use in a populated area if the per-capita water use is known. The per-capita use equals the total volume of water delivered to an area in a time period (say, in a calendar year) divided by the total population served in the area in question. The per-capita use changes over time with changing cultural practices (see Loáiciga and Renehan, 1997). Lippincott (1905) estimated a per-capita water use in Santa Barbara of 379 liters per day. This implied a total consumption of slightly over 3 million liters of water per day by a population of 8045 people (the 1903 official population).

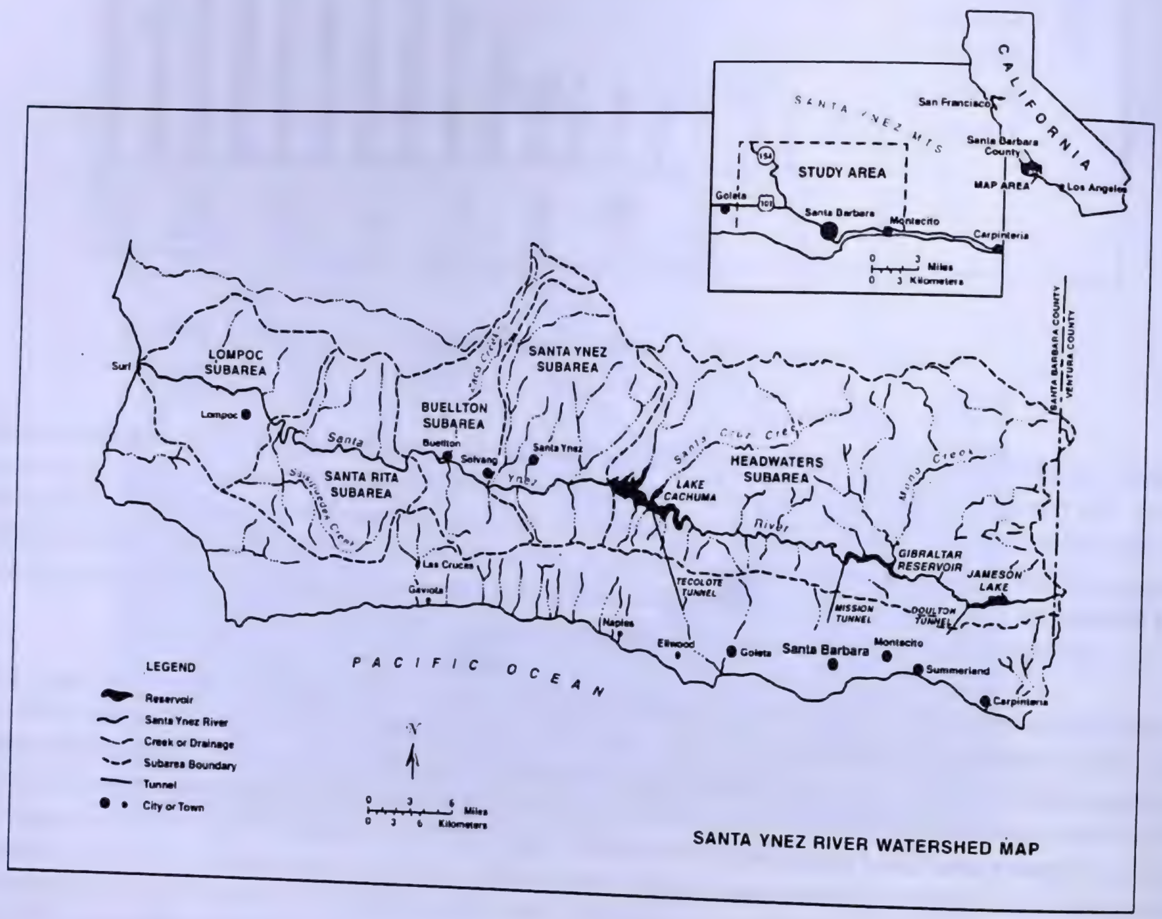
In spite of the population undercounts mentioned earlier, the fact that by 1900 there were, according to official records, 6587 individuals in Santa Barbara compared to the 200 reported in 1788, suggests the extent of the mounting pressure on local water sources. This was exacerbated by recurrent dry periods in the second half of the 19th century in an area that did not possess inter-annual water storage facilities. Life at the time was heavily permeated with the pioneer spirit. Local government was incipient and weak. It is no surprise then that water supply in Santa Barbara was in the hands of private water dealers and investors who created the Mission and De la Guerra water companies in 1872 and 1887, respectively. Incidentally, circa 1872, 3.785 cubic meters of water (a standard counting unit at the time, equal to 1000 gallons) sold for fifty cents of a dollar in Santa Barbara (Eckman, 1967). A merger of the Mission and De la Guerra water companies in 1889 created the Santa Barbara Water Company, which became a major actor in Santa Barbara's waterscape until 1911, when it sold its assets and water rights to the City of Santa Barbara.

By the late 1800's it became clear that local government and public resources had to be involved in developing more secure water supplies for Santa Barbara. City Engineer George F. Wright provided a path-changing advice to City Council when, in 1889, he reported that the local water supplies were not sufficient to meet future water use and that inter-basin water imports from the neighboring Santa Ynez River were the solution to Santa Barbara water problems. This visionary opinion was confirmed by Lippincott (1905) in a study of the Santa Barbara water problems, which, among other things, recommended that a storage and diversion reservoir be constructed in the Santa Ynez River at the Gibraltar site. Figure 5 shows a diagram of the Santa Ynez River basin and its modern-day water storage facilities, among which is Gibraltar Reservoir.

Water-Supply Reservoirs of the 20th Century

Since 1900 there have been endless efforts to achieve "reliable" water supplies for the City of Santa Barbara. The target, however, keeps moving due to changes in water use and access to water sources. An important step was achieved in 1912 with the completion of Mission Tunnel, a 5,962-meters long excavation under the Santa Ynez Mountains. The tunnel would eventually bring, by gravity, water from Gibraltar Reservoir to Santa Barbara. Gibraltar Reservoir, the first one in the Santa Ynez River came to fruition in 1920. Gibraltar Dam rose 53.3 meters above bedrock and 45.7 meters above the river's channel. It had a full-capacity impoundment of 17.9 million cubic meters.

Figure 5: The Santa Ynez River Basin and Water-Storage and Conveyance Structures Within It.



The impoundment of the Santa Ynez River raised the concerns of downstream communities that saw their riparian rights to the river's water threatened by Santa Barbara's diversions at Gibraltar Dam. In particular, the City of Lompoc, near the estuary of the Santa Ynez River, has continued its legal battle against upstream diversions of the river's water to the Santa Barbara County's south coast to this date.

In 1928 the Montecito Water District, the public water purveyor of Montecito, completed its Juncal Dam, located upstream from Gibraltar Reservoir (see Figure 5). Jameson Lake, impounded by Juncal Dam, had an original capacity of 9 million cubic meters. The construction of Juncal Dam netted the City of Santa Barbara 370,000 cubic meters of water per annum in perpetuity from the Montecito Water District, a consequence of a pact between the neighboring communities. Additional water supplies were developed as a result of the drought of the late 1920s and early 1930s (see Figure 2), which forced the City of Santa Barbara to construct several deep emergency ground-water wells by 1931.

By 1945, brush fires and erosion had silted Gibraltar Reservoir and reduced its storage capacity to about 9.2 million cubic meters. In 25 years, the reservoir's capacity had been nearly halved, and Santa Barbara was again vulnerable to water shortages. The situation was compounded by a punishing drought in the second half of the 1940s (see Figure 2). Early 1948 saw the first water rationing ordinance enacted in the City of Santa Barbara. The raising of Gibraltar Dam to restore its impounding capacity to its original 17.9 million cubic meters was authorized in 1948. This project was finished in 1949. Although reassuring, the raising of Gibraltar Dam did not change the fact that an empty dam is of little help. There was growing consensus among water purveyors in the South Coast (Carpinteria Water District, City of Santa Barbara, Goleta Water District, La Cumbre Water Company, Montecito Water District) and in the Santa Ynez Valley (the Santa Ynez River Water District) that a cooperative effort was needed to build a reservoir in the Santa Ynez River downstream of Gibraltar Dam with multi-year carryover capacity. Hydrologic studies of the Santa Ynez River's streamflow had established a reservoir capacity on the order 259 million cubic meters. The United States government, through the Bureau of Reclamation, would have to be part of the reservoir construction project for financial reasons and because part of the planned reservoir – to be named Cachuma Lake later on - was located within federal land.

In 1949, voters in Santa Barbara County's South Coast and Santa Ynez Valley approved the inter-agency agreements for the construction of Bradbury Dam to create Cachuma Lake with a storage capacity of 253 million cubic meters. A feature of this water storage and inter-basin diversion program was the Tecolote Tunnel, a gravity tunnel to convey water from Cachuma Lake to the South Coast (see Figure 5). Once past the Tecolote Tunnel, Cachuma water would be treated at a modern drinking-water treatment plant (Corona del Mar) and then distributed westward by means of the South Coast Conduit to various project-member communities in the South Coast. The South Coast Conduit is a 42-km long buried pipe ranging from 68.6 cm to 121.9 cm in diameter.

Bradbury Dam and the South Coast Conduit were completed in 1953, and Tecolote Tunnel in 1956. In addition, the City of Santa Barbara built its own modern drinking water treatment plant (the Cater Treatment Plant) in 1964 with a daily treatment capacity of 37.85 thousand cubic meters, which was upgraded to 45.6 thousand cubic meters years later. The Cater Plant treats water from Gibraltar reservoir and Mission Tunnel. The most important water-supply infrastructure for Santa Barbara and other surrounding communities had been achieved. Yet, the struggle for a reliable water supply did not end at this time.

The State Water Project and Ocean Desalination

While Santa Barbara struggled to get a grip on its water shortages, the State of California as a whole was facing similar problems. In the mid 1950s California embarked in the construction of the State Water Project (SWP), a complex network of reservoirs (the largest ones found in northern California), diversion and conveyance structures, and pumping stations that move water from water-rich regions of the State in the Sacramento and San Joaquin basins to other less endowed areas, such as coastal central California, the Central Valley, and, primarily, to southern California. Although the original layout of the SWP has been built, it continues to grow piecemeal as of this writing.

The SWP allocated a target water delivery of some 55.5 million cubic meters per year to Santa Barbara County, of which the City of Santa Barbara was entitled to 3.7 million cubic meters. Yet, at that time, the construction of Cachuma Lake had brought a sense of self-sufficiency to the City and County. Therefore, the disbursement of funds to construct the conveyance structures needed to bring water from the SWP's distribution network to Santa Barbara was deemed unnecessary and was not pursued. By the early 1970s, a strong anti-growth coalition had emerged in Santa Barbara. The anti-growth group understood that the precarious balance between water use and local water supplies (i.e., the Santa Ynez river and ground water) was a powerful political tool to slow down urban sprawling in their coveted seaside community. Opponents argued that water was being used as an artifice to hinder growth, thus producing exorbitant real-state prices, choking economic development, and causing a decline in the quality of life for the financially disadvantaged in Santa Barbara. They saw State Water Project imports as the most practical way out of the conundrum. Nevertheless, the anti-growth forces prevailed in their quest to depend on existing local water sources only, at least until 1987.

In 1987, a drought started that would last until 1992 (see Figure 2). Although not the longest nor driest drought on record, this drought hit at a time when the population that depended on the Santa Ynez River had reached levels never seen before. By mid 1990, the Gibraltar and Jameson reservoirs had dried up, and Cachuma lake was on its last water reserves. Ground-water wells were tapped heavily and their production had declined considerably. Santa Barbara faced the possibility of running out of water in a few months. Water pricing went from the century-old flat-rate system to a increasing-block rate structure aimed at discouraging water use beyond the satisfaction of basic needs. In October of 1990, 3.785 cubic meters of water sold for $3,600 in Santa Barbara, a far cry from the fifty cents paid in 1872! Other water-conserving measures were also implemented at the time to institute long-term water savings (Loáiciga and Renehan, 1997).

The last six months of 1990 and the winter months of 1991 saw developments that had been held back for almost thirty years. In 1991 Santa Barbarans approved the construction of a $ 35 million sea-water desalination plant with a maximum annual treatment capacity of 12.33 million cubic meters. At the same time, Santa Barbara County voters passed a ballot authorizing the expenditure of half a billion dollars to build the conveyance facilities needed to import the County's SWP's water allocation. The calls of the anti-growth group for spending restraint and to develop a larger desalination plant that could satisfy water use from local and flexible sources were drowned in a sea of anti-drought anguish.

The waterscape of Santa Barbara had gone through another quantum leap. The water-transport facilities to import SWP water were finalized in 1998, while the desalination plant was completed in mid 1992 but never used because by the time it came on line, the water-supply reservoirs had filled up again: the drought had ended officially in the winter of 1992. Eventually, the desalination plant's filtering membranes were sold and other land-base, replaceable, infrastructure was removed and stored. However, the sea-water intake line and pump, as well as the pipelines that connect desalinated water to the City's water-distribution network remain in place, ready to be activated on short notice (six months) when the next drought strikes.

Conclusion

New challenges have arisen regarding the operation of Cachuma Lake. The listing of the steelhead trout as an endangered species in the Santa Ynez River has introduced a new set of minimum-flow requirements downstream of Cachuma Lake. Other endangered species, such as the red-legged frog and the least-bell vireo (a bird), pose limitations to the diversion of tributary streams and to the further raising of dams in the Santa Ynez river, respectively. It is relevant to ask at this juncture whether or not Santa Barbara has solved its water-supply problems. Our answer is affirmative, in spite of new ecological challenges and the fact that Gibraltar and Cachuma storage capacities have been reduced by siltation to 8.6 and 234 million cubic meters, respectively. Part of the answer to drought weathering lies in skillful management of reservoirs, the State Water Project, and ground water.

Ground-water sources pose unique challenges, because the Santa Barbara aquifer is of limited extent and yield and is threatened by sea-water intrusion (Loáiciga and Leipnik, 2000). These limitations led to the current ground-water management plan whereby ground-water is a "back up" or emergency supply to be used during droughts only (City of Santa Barbara, 1994). In normal and above-average rainfall years, water supply is to be met by surface waters while ground-water wells are rested and the aquifer is allowed to replenish. During drought, Santa Barbara's long-term water supply plan (City of Santa Barbara, 1994) calls for pumping of up to 5.5 million cubic meters per year. Other studies have shown that Santa Barbara's aquifer yield may not be sustained above 2.5 million cubic meters under drought (Loáiciga and Leipnik, 2000). Thus, ground water plays a limited role in the water-supply picture of Santa Barbara during long drought periods.

In the final analysis, however, the key to emergency and long-term water needs rests on the ability to tap virtually unlimited sea water resources by desalination, albeit with the realization of its intrinsic higher cost. This is the likely water-supply solution scenario for the big urban coastal centers of southern California as well.

Acknowledgments

The author was assisted by Mr. Chris Keith, Mr. Luke Hamlin, and Ms. Jennifer La Cava in the gathering of historical information and the preparation of Figure 3. The author received partial support from the California Water Resources Center and the United States Geological Survey to conduct this research.

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Notes:

1. The City of Santa Barbara's El Estero Waste Water Treatment Plant was built in 1979, with a daily treatment capacity of 41.6 thousand cubic meters of sewage. This plant provides secondary treatment to the City's sewage. The treated effluent is discharged to the Pacific Ocean. In the mid 1990s a sewage reclamation plant was built to "reclaim" and recycle sewage water to be used for the irrigation of parks and golf courses.

Landmarks of Santa Barbara

by
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Have you ever been lost? If so, chances are that your first reaction was to look around for some feature, sign, or landmark that would help reorient you. In general, landmarks play an important part in environmental knowing and in wayfinding, and constitute key spatial components of one's cognitive maps.

It is sometimes argued that instead of developing a single cognitive map people develop a cognitive atlas. This atlas would contain representations of many different environments at many different scales. Depending on the purpose behind a specific problem solving task (e.g. regaining orientation), specific components of the cognitive atlas would be accessed. The question immediately arises as to whether such a cognitive representation is simply an internalized individual geographic information system.

In the language of the geographer, the most comprehensive spatial knowledge system should contain the following properties:

1) Individual "occurrences" of different types of spatial phenomena
2) Spatial distributions of occurrence classes of phenomena
3) Spatial processes that account for the development and patterns of spatial phenomena
4) Spatial contiguity and spatial association
5) Linkage and connectivity
6) Geographic regions
7) Spatial stratification and hierarchies
8) Spatial structure

Spatial knowledge consists of some combination of points, lines, areas, and surfaces. Individually and in combination these appear to be capable of recognition and have become accepted parts of declarative knowledge systems. Together they comprise what Kuipers (1978) called a "common sense" spatial knowledge structure. However, in both the natural environment and the transformed, or built, environment, understanding comes not only from knowing what is where (i.e., location), but also how different things fit together. This includes knowing higher level concepts such as hierarchy, surface, association, connectivity, pattern, and so on.

Perhaps the single greatest influence on geographic research on spatial cognition was Lynch's (1960) book, *The Image of the City.* Lynch argued that built environments (such as a city) could be decomposed into sets of two dimensional components - landmarks, nodes, paths, boundaries, and districts. Higher order geometric properties were ignored in favor of these basic components. The easiest of these components to work with were landmarks and routes. They had a well defined existence in objective space and could be designated at specific places in the environment. People could express their knowledge of landmarks - theoretically, the most dominant and most widely known features in an environment. Similarly, people could readily identify routes that linked landmark locations or segments of environments, and their physical existence could similarly be pinpointed. Lynch suggested that this is how complex environments were encoded and stored in long-term memory, acting as a frame for organizing other sensed environmental information. Thus, when people were asked to sketch what they knew of a place, they would invariably use the point/line/area conventions of standard graphic, geometric, and cartographic representation to illustrate their knowledge base. Of course, such sketches would not represent their total knowledge structures, which may include non-spatial information (e.g., feelings of habitability or danger). Despite problems that arise if one attempts to re-assemble such decomposed images (Gale, Golledge, Pellegrino, & Doherty, 1990), this remarkable conceptualization stimulated research in geography and many other disciplines.

For the geographer, the simplest geometric feature is the point. Each point is an occurrence with identity, location, magnitude, and time dimensions. Information on all of these can be collected and represented visually in carto-graphic form. Comparisons can be made between estimated and actual locations, and between other subjective and objective relations. Since location was perhaps the most important single concept for the geographer, and the land-mark lent itself readily to locational analysis, much geographic research on urban images in the 1960-1980 period concentrated on these types of occurrences. Much of the research on cognitive maps, for example, involved recov-ering locational patterns of well known places in different environments, then comparing the recovered pattern to existing patterns (Golledge, 1977; Buttenfield, 1986). While the psychologist or the planner/designer focused on characteristics that made a landmark easily perceivable (i.e. its legibility), the geographer focused on locational ac-curacy. Landmarks still provide the easiest spatial form (i.e., point patterns) to work with and still dominate much of the geographically relevant cognitive mapping research.

Besides their imagibility, however, landmark definition was seen as a critical stage in the evolution of spatial knowl-edge. Hart and Moore (1973) discussed the evolution of spatial knowledge from egocentric to allocentric frames of reference, from topological to fully metric and geometric understanding, and from landmark to route and survey types of knowledge. The latter transition was later popularized in psychology by Siegel and White (1975). Golledge (1978) postulated an anchor point theory of spatial knowledge acquisition in which landmarks acted as critical or-ganizing nodes, dominating other environmental information in their vicinity. This theory was hierarchically organ-ized with a critical set of landmarks acting as primary nodes or anchors and dominating segments of space (nodal regions) in which successively lower ordered sets of nodes, routes, and areas could be identified. As one went fur-ther down the hierarchy, characteristics such as locational precision, unambiguous identity, magnitude measures, or even temporal awareness, diminished. Landmarks or anchor points acted as reference nodes for spatial organiza-tion and for integrating discrete bits of information into distributions and patterns capable of being imaged, exter-nally represented, and analyzed.

Cities change over time, and their landmark structure changes as new features and new places emerge. Table 1 shows some evidence of these changes. Columns 1 and 2 provide lists of dominant landmarks collected from spa-tially stratified samples of local residents in Santa Barbara in 1978 and 1992. For example, only 8 of the 21 most frequently mentioned places in 1978 reappeared on the 1992 list, while 9 were included in the 1997 list. These are the landmarks that "anchor" images of Santa Barbara that may be considered the "common" landmarks - i.e. the ones most likely to appear on the landmark list obtained from any randomly sampled person in the Santa Barbara area. The remainder consist of "secondary" or lower-order places that are less common or (more likely) are "idiosyncratic" - i.e. important only to a few people (or one person); such as "my home" or a favorite dining or en-tertainment place.

Table 2 shows the regional breakdown of landmarks in 1992 (for region location see Fig. 1). The top 6 ranked landmarks in each of the 4 "regions" of the Santa Barbara-Goleta-Montecito area are shown. For example, Area D (University and Goleta) has dominant landmarks relating to travel (airport), education (Storke Tower/UCSB/ UCen), shopping (Fairview and Pacific Oaks/University Village Shopping Centers) and recreation (Sandpiper Golf Club and Goleta Beach Pier), of which only the Airport and Storke Tower are generally acknowledged as major city-wide landmarks). The downtown Santa Barbara region includes places of historical/architectural dominance (Courthouse, Mission), a distinct feature (Shoreline Lighthouse), recreational places (Oak Park, Hendry's Beach), and a tourist area (Stearn's Wharf). Of these, Courthouse, Mission, and Stearn's Wharf are recognized as "city-wide" or "anchoring" landmarks. This table shows that the landmark structure of a place for local residents in-cludes not only the "common" or anchoring points, but also places of local importance - and that the places com-prising the latter have a significant regional component.

The final column of Table 1 reports not so much on a citywide perspective on landmarks (as is the case with col-umns one and two) but on a regional perspective. This represents the dominant reported features of a sample of younger Goleta residents. Immediately noticeable is the significant increase in the number of social/recreational places reported (e.g. Freebirds, Brickyard, Borders, Cucas, King's Tavern, Earthling Bookstore). There is also a change in the dominant feature of a local shopping center (Sears replaces Robinsons as the anchor at La Cumbre

Shopping Center) fast food restaurants emerge as significant places (Taco Bell, In and Out Burger) and restaurants listed are those where social gatherings are encouraged (Alex's Cantina, Brophy Brothers Restaurant). Possibly re-flecting a university student component in the sample, places like the UCSB and Santa Barbara libraries, Santa Bar-bara Art Museum, Earthling and Borders Bookstores, emerge as significant landmarks. UCSB locations (Sands Beach, Ellison Hall, Rec Cen, Francisco Torres dormitories, and UCen) reflect local regional importance, and sister institutions such as Santa Barbara City College and Santa Barbara High School are added.

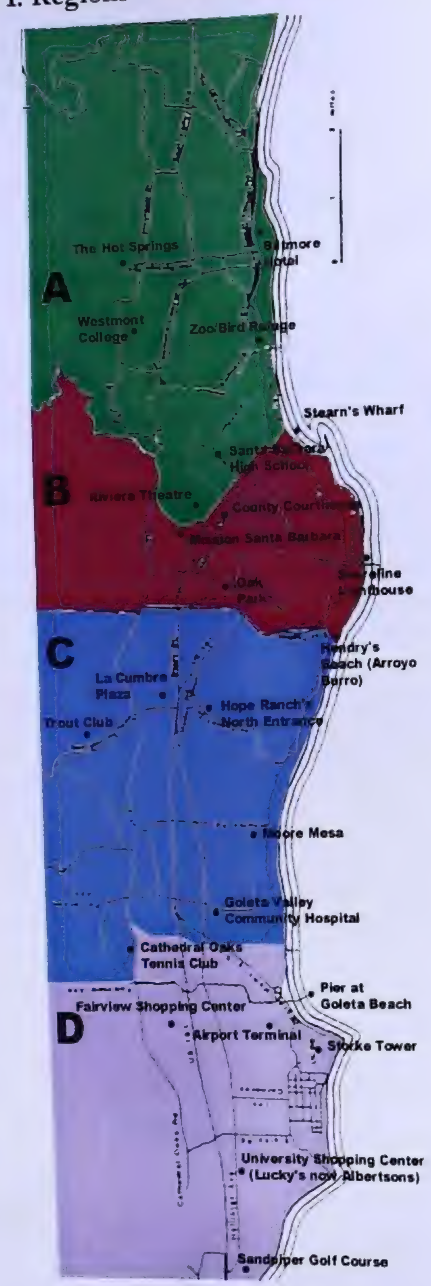
Table 1: Santa Barbara Landmarks: 1978, 1992 and 1997

1978	1992	1997
La Cumbre Plaza	Airport Terminal	Home
Santa Barbara Airport	Biltmore Hotel	UCen
County Courthouse	Cathedral Oaks Tennis Club	Lucky's (Pacific Oaks - now Albertson's)
Mission Santa Barbara	County Courthouse	Sears (La Cumbre)
UCEN Building at UCSB	Fairview Shopping Center (Vons)	Stearn's Wharf (Santa Barbara Harbor)
Goleta Beach	Goleta Valley Community Hospital	Ellison Hall
FEDMART, Goleta	Hendry's Beach (Arroyo Burro)	Paseo Nuevo
Santa Barbara Harbor (Stearn's Wharf)	Hope Ranch's North Entrance	State Street
Botanical Gardens	The Hot Springs	Library (UCSB)
Robinson's Department Store (La Cumbre)	La Cumbre Plaza	Santa Barbara City College
Dos Pueblos High School, Goleta	Mission Santa Barbara	Rec Cen at UCSB
Arlington Theatre	Moore Mesa	County Courthouse
Santa Barbara Museum of Art	Oak Park	Storke Tower at UCSB
Magic Lantern Theatre, Isla Vista	Pier at Goleta Beach	Brickyard
Piccadilly Square	Riviera Theatre	Santa Barbara Mission
Bank of America, Isla Vista	Sandpiper Golf Club (Clubhouse)	Francisco Torres
YMCA	Santa Barbara High School	Borders
Rob Gym at UCSB	Shoreline Lighthouse	Cuca's
Greyhound Bus Depot	Stearn's Wharf (Santa Barbara Harbor)	Arlington Theatre
Storke Tower (UCSB)	Storke Tower	OSH
Airport Terminal	Trout Club	Santa Barbara Art Museum
	University/Pacific Oaks Shopping Center (Lucky's/now Albertson's)	Santa Barbara Library
	Westmont College	Wells Fargo Bank (Fairview Center)
	Zoo/Bird Refuge	Shoreline Park
		Brophy Brothers Restaurant
		Cliffhouse (Devereux) - Campus Point
		King's Tavern
		Santa Barbara Airport
		Taco Bell (Fairview)
		Woodstock's
		Botanical Gardens
		Sands Beach
		Wildcat
		Alex's Cantina
		Campbell Hall
		Earthling Bookstore
		Freebirds
		In and Out Burger
		Santa Barbara YMCA

Table 2: Top Ranked Landmarks by Regions:

A	B	C	D
Biltmore Hotel	County Courthouse	Cathedral Oaks Tennis Club	Airport Terminal
The Hot Springs	Hendry's Beach (Arroyo Burro)	Goleta Valley Community Hospital	Fairview Shopping Center (Vons)
Riviera Theatre	Mission Santa Barbara	Hope Ranch's North Entrance	Pier at Goleta Beach
Santa Barbara High School	Oak Park	La Cumbre Plaza	Sandpiper Golf Club (Clubhouse)
Westmont College	Shoreline Lighthouse	Moore Mesa	Storke Tower
Zoo/Bird Refuge	Stearn's Wharf	Trout Club	University Shopping Center (Lucky's/now Albertson's)

Figure 1: Regions of Santa Barbara/Montecito/Goleta



What is revealed in these tables is the dominant anchoring landmark structure of Santa Barbara (Courthouse, Mission, Stearn's Wharf, and Santa Barbara Harbor area), important places of activity in the surrounding area (Airport, major regional Shopping Center/La Cumbre), distinct places on the UCSB campus (Storke Tower and UCen), and the Goleta Beach recreation area. Other environmental cues reflect regional or idiosyncratic preferences.

It should be noted that, since 1997, a major new shopping area has developed in Goleta, anchored by Costco. Probably, today it would equal or replace La Cumbre as a dominant shopping center landmark. Growth and change has altered other cues - e.g. Fedmart was closed and replaced by a regional US Post Office and has (after that left) become illegible in terms of place recognition. Businesses have flourished and died, as have places of recreation, entertainment, and dining. The old Isla Vista Bank of America (burned during the Vietnam Riots) has gone through several transitions and has also lost its place specificity. Downtown, State Street has evolved into a planned shopping and tourist dominated area with distinct anchors such as Paseo Nuevo. After a brief period of "cognitive decline" when the architecturally inspiring Arlington Theatre was replaced by the Artsy Riviera Theatre, the Arlington Theatre has recovered its landmark dominance.

As cities change, the distinctive features that give the city character and legibility change with it. But, while new landmarks emerge and compete for dominance, often established traditional places anchor both images of residents and visitors alike. These anchors provide the most impressionable and most easily recalled features of a city, and usually factor into verbal, film, video, and written descriptions and communications about places. Landmarks anchor and give substance to our images of places. If there are no really distinct natural or built environmental features in an area, we attached significance to places so that identifiable and communicable place-based meaning can be given to a local environment. Luckily Santa Barbara has a range of distinct natural and built features that have provided an easily recognizable landmark structure both at present and in the past.

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Preserving Open Space: The Special Challenge of the Foothills

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Twenty-five years ago, I was leading a small band of children on a hike and got lost. I shouldn't have; the land was near my home and familiar to me. I had been hiking it off and on since we moved to the area in 1968. But it has a complex topography, and this time it fooled me into going down into an overgrown canyon I'd never explored before. It was fine canyon, with a creek, a stand of riparian oak, and some coastal scrub on the upland. The children were having a good time, and I wasn't worried about getting back. And shortly we did get back, emerging into familiar territory, though it was a new and mildly surprising place of exit about 400 yards west of where we usually came out. There was a man in a pick-up truck, and when we climbed through the fence he yelled at us: "What the *hell* are you doing on this land?" I went over to the truck, where I saw that he was a pretty raw-boned and weathered old guy. I told him that we had been out on a hike and got lost. "What's yer name?" I told him. "Do you know this is private property?" I said, yes, but that we had been hiking on it for years and nobody had complained. This was a strategic mistake. I was about half way back to the children, when he yelled at me "Hey!" He was leaning out of the truck window with a look of triumph on his face. "If you've been hiking this land for years, how come you got lost?"

It was a good question. I love to hike, but I am not like some geographers who have a kind of global positioning system in their brains that lets you know at any time exactly where you are, even in complicated caves deep under the earth. I don't have that mechanism. Nor do I have a very precise visual memory. So I tend to get lost. But I do love the out of doors, and I think it would be pretty hard to argue that my diminished capacities make me any less appreciative, and hence deserving, of the pleasures of the wild. Given a choice, I'd prefer to be out there walking around, and, in this, I am like a great many people. Still, that doesn't give us the right to trespass. The old man had a point. It turned out he wasn't the owner. He had been hired by the owner, someone who had recently acquired the land and was anxious to keep people off so he could develop it.

In this dream of development, the owner had many forerunners. The property he bought is 377 acres of extraordinarily rich foothill land just inside the urban boundary of Santa Barbara. From down below, on the Highway 101 corridor, its gently rolling hills pop out at the eye, gorgeous and green for half the year, soft California gold for the rest. As it took shape over the millennia, somehow this parcel of land managed to escape most human predation. The Indians, as was their practice, left it the way they found it. For the last century and more, cattle have been grazing there (on an ordinary day there are roughly fifty head), and part of the southern acreage was farmed a few generations ago. But that's about it. All eight foothill habitats are still represented in these acres – chaparral, coastal scrub, grasslands, oak riparian, oak Savannah, oak woodlands, wetlands, and willow riparian. Animal life is abundant, including well over 100 species of birds.

All of which is a kind of miracle, since it is what is called "prime real estate." Around 1970, shortly after we moved here, a man from Pasadena took an option on the land and drew up a proposal for 1200 units. This failed and was succeeded by other proposals, including a golf course, a retirement community, and a "Christian City on the Hill," equipped with everything one would need in this world from cradle to grave. All these proposals failed as Santa Barbara's growing environmental sensitivity kept one step ahead of developers' ambitions. In keeping with this logic, the most explosive issue in this series was the least ambitious that the land had yet seen – a 350-unit development called "Royal Gate." The boss of the old man I met was deeply involved in this project. But resistance galvanized the community and, when it too failed in the early 1980s, conservatives and liberals on the Board of Supervisors joined together to hammer out what seemed to be the final word in zoning for the land: a maximum of 75 units, clustered in the most ecologically appropriate way.

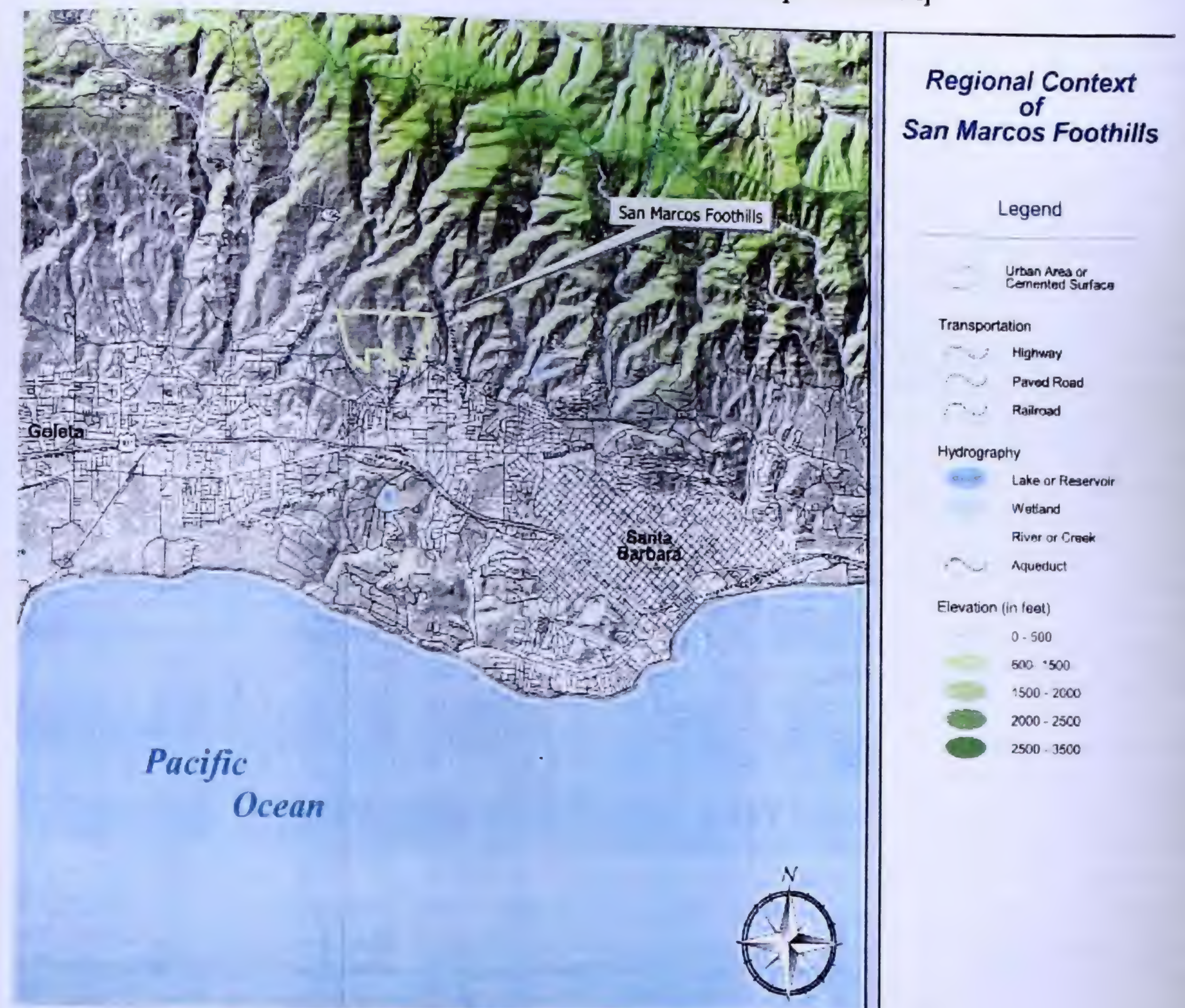
[Picture 1: Early Morning Oak, San Marcos Foothills. Photo by Morgan Ball]

But the environmental screws kept turning, and by the nineties they were tighter still. Two proposals emerged in the last decade of the century, both of them within the new guidelines of 75 clustered units. The second of these, Bridle Ridge, made it all the way to the Planning Commission where it was struck down on a 5-0 vote of rejection. That was two and a half years ago. Since then, yet another developer, a "green" one, has taken an option on the land. His proposal is for 12 units with over 200 acres in a conservancy arrangement. He has been working on this for the better part of two years now, but as of this writing he has yet to submit an application. You can understand why he might hesitate.

It must seem very unfair. It is easy for environmentalists to demonize developers, but by and large they are just people, like anybody else. And though there is big money to be made in development, there is also a lot of risk. To go into that business, you have to like the creative challenge of an enormously complex enterprise involving intricacies of design, construction, budgeting, bureaucracy, and politics. The man who thought up Bridle Ridge was an intelligent, decent individual who built a team, invested several years of his life, significant money, and untold hours meeting with neighbors and fine-tuning his design. It took a toll on his heart, literally.

So, granted, developers are no more rapacious and demonic than environmentalists are brainless and self-indulgent. Some of each there may well be on both sides, but this is neither interesting nor significant. What is in fact going on here is a familiar clash of cultural values that fall into two clusters – those of preserving the environment and those of private property – played out in a complex entanglement involving the law, money, and politics. If the latter three all tend to reduce the complexity of this clash, and if politics, especially, tends to reduce to a contest of good guys and bad guys, politics is also an art of compromise. But then if it is, shouldn't the environmentalists, bent on preserving these acres, practice this art? After all, the only really sure thing about politics is that it goes through cycles. Change one seat on the Board of Supervisors so that 3-2 votes go the other way, and Bridle Ridge might wind up looking like a lost opportunity.

[Picture 2: Ariel photo of Santa Barbara with map overdrawn]



For that matter, many, perhaps most, environmentalists are also owners of private property. Thirty years ago a group formed in Santa Barbara called The Foothill Preservation League, whose mission is summed up in its name. It thrives today, with a substantial membership, of whom many not only own homes but the land that goes with them. When Bridle Ridge crashed and burned in 1999, the FPL joined other groups and individuals to create a new group – the San Marcos Foothills Coalition – dedicated to preserving the 377 acres that serve as my example in this piece. Much of this now quite large and enthusiastic group are homeowners and landowners as well. Is this then a case of "we've got ours but you can't have yours"? Perhaps this is an inevitable charge, but three points can be made in response. One is that most of these homeowners bought into an area already developed. Another is that the mere pre-existence of houses does not justify the continual production of houses. No one would like to see wall-to-wall development. So the question is where do you draw the line? As a community, what do we want to preserve?

The third point is that the whole intention of the group is not to abrogate the laws of private property by taking the land, but to honor them by buying it. After the Bridle Ridge option ran out, the new Coalition located the owner, who also turned out to be the owner of a restaurant chain headquartered in Anaheim. He had picked up the land in a fire sale after the boss of the old man I met went bankrupt. The Coalition asked to meet with him; he agreed to come up; and in the summer of 1999 both parties met together in the Goleta Public Library. Within an hour, the owner of Specialty Restaurants told the Coalition that if they could raise $10 million in 6 months, the

land was theirs. He then had to leave quickly to see a man about buying a World War II bomber (he collects old planes). His offer (the $10 million) never did get written up, despite numerous entreaties from the Coalition's lawyer, and before long the green developer was on the scene with an option to develop, while the rumored price of the land had gone through the roof. No one knows what the owner would really accept for outright purchase, but then the rumored new price might simply be a ploy, at this stage, to discourage any thought of buying the land for public ownership.

If the San Marcos Foothills Coalition is willing to buy the land, then the clash of values that is going on here is clearly subtler than a clash between communistic appropriation and capitalistic exploitation. It has to do rather with a kind of ratio of comparative distress: what the two parties – the developers and the environmentalists – have to put up with in order to achieve their ends on any particular issue. You can see it in the progression I outlined at the beginning of this essay. In that progression, you might say that the ratio of distress has steadily mounted on the developers' side (though, of course, examples abound where the converse is true; I'll get to some shortly). Moreover, though the green developer – an enormously likeable gentleman, with a childlike demeanor that belies his native shrewdness – seems to be winning at the present time, the Coalition, undaunted, continues to augment the noise and visibility of its presence. With the help of modest contributions, it recently unveiled a plan of stewardship to let the public know how it proposes to care for this land once it takes ownership. The announcement was carried off on site and with fanfare – jugglers, music, speeches, wildlife exhibits – and a wealth of media coverage. All this activity raises the ante, as both parties are well aware. By getting the word out, focusing attention on the integrated biotic complexity of the land and showing themselves to be responsible stewards, the Coalition changes the level of community awareness within which the developer has to make his case, not to mention look green at the same time. His distress rises.

I should note that representatives of the Coalition have been meeting with this developer for about a couple of months now, and shall continue, as both parties try to find some common ground on which to negotiate. All the details are confidential, of course, but far and away the spirit of the Coalition membership is to keep pressing for the whole thing. Yet, given this unbending stance, what has happened to the art of compromise? Is there after all a black and white issue here that is beyond political compromise? Well, as a matter of fact, most of those involved would say, yes, there is. But to see it depends on shifting the focus from the *rights* of private property to the *value* of development. Looked at in this light, it becomes suddenly, blazingly clear that development in these foothills is of *no value at all*. None. Unless one counts the brief period of employment it takes to build these projects.

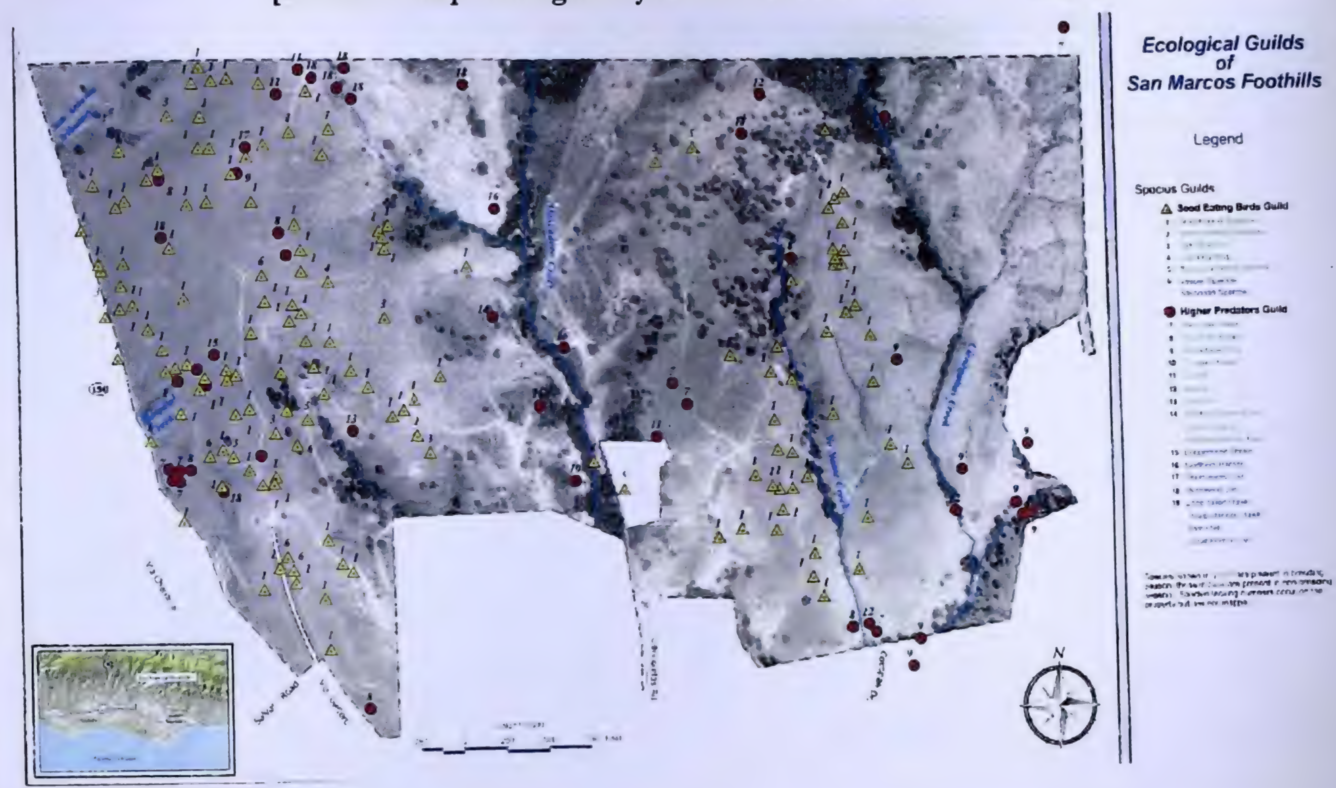
The argument for the benefits of transient employment is almost as weak as the argument for housing. Proponents argue that there is value in increasing the housing stock in Santa Barbara. Many in the San Marcos Foothills Coalition would agree: we need housing stock. Some are "New Urbanists," some are not, but all would agree that the kind of housing we need is affordable housing, and nothing that goes up on this prime real estate, with its wide-angle views of Santa Barbara and the Pacific Ocean, is going to be affordable. The green developer has thrown out $800,000 as a possible price for the cheapest, least attractive of the 12 lots he imagines for this land. That's only for the land and the right to build on it.

Proponents of development argue that local people will move up into these 12 lots, freeing up more affordable housing in the city. But this, too, is a weak argument, with no statistical support. The chances are that those who buy will be people from out of town, people with megabucks who would like to retire in Santa Barbara (as would the current owner of Specialty Restaurants). They bring hardly a thing to this town that we need. The taxes they pay will barely cover, if at all, the costs they incur in services. Opening up the foothills for people of such wealth, moves Santa Barbara that much closer to towns like Aspen, Colorado, where, in the deathless words of Molly Ivins, there are no "normal people" anymore. All the necessary folks who weed the gardens and serve the meals and fix the cars and clean the houses in Aspen live somewhere else. They come in by bus.

If this has not happened yet in Santa Barbara, the colonization of open space by a narrow band of extraordinarily wealthy people continues to happen. And if developers so far have come to grief on these particular 377 acres, the overall ratio of comparative distress has steadily shifted against advocates of foothill preservation. In the nineties,

a number of large fortunes were translated into real estate in the Santa Barbara foothills. This was not bad in itself, but the inevitable corollary was the development of the real estate, and this can only be counted as a net loss, especially because what has been built has been very big. This may reflect a national shift in psychology. In the past, if one built in the hills, one usually built a hideaway. This would be appropriate: a discreet structure that allowed you to enjoy the view without being viewed yourself. If I am right about this, then something in the national character has changed, since the object now is not only to enjoy the view but to enjoy being viewed enjoying the view. Of course, there is raw economic good sense operating here, too. The best way to insure a maximum resale value of prime real estate is to build large structures on it – though this "good sense" trades on the same psychology. What it has meant in practice is that the tops of hills have been methodically sliced off and then, on the raw and scraped surface of the earth, truly mammoth structures have been placed, at times exceeding 10,000 square feet. Hiking up above Montecito not long ago, I saw a new one and counted six garage doors.

[Picture 3: Map of the guild systems on the San Marcos Foothills]



The result of any of these transactions is devastation well in excess of the size of the estate. Whole eco-systems are destroyed. Nesting areas and foraging routes are laid waste. And since brilliant lights are left on all night (in keeping with the above psychology), the lives of nocturnal creatures are made considerably more difficult. There are, of course, animals who survive all this, even thrive on it. They are called rats. And also ants (from Argentina), and crows, and possums, who will eat anything anywhere. What disappears is diversity. And even the most non-political of biologists will tell you that, in the scale of earthly values, biological diversity is a good thing.

During the public input stage of the Bridle Ridge hearing, the last citizen to speak began by disbursing compliments to the developer, his agent, his architect, his lawyer, and all the members of the team. "You guys are the best," he told them, as their smiles widened. "You're the best at what you do, each of you. You are the best . . . [and here he paused] . . . of the whalers." There was a muted gasp. The smiles froze. He went right along developing his conceit, enlarging on how they had the fastest boats and the sharpest harpoons. He was clearly prepared to go much further but was mercifully stifled by the chair of the Planning Commission. And a good thing, too. This was an awfully personal attack, and the targets were good people. I believe this deep down – that as people they are, at the least, no worse than the rest of us.

All the same, it was a small stroke of genius. The speaker (now the president of the Coalition) simply brought out what we all know but rarely put so well: that open space on the urban border is rapidly going extinct. It is being hunted down for profit. And the values served by this hunt are minuscule in comparison to the values that are sacrificed. As each of these drab and undistinguished modern-day castles goes up, we witness a separate extinction. We trade away a wealth of biotic diversity and a landscape that, in its essentials, has endured longer than there have been humans here to observe it – we trade all this to serve the pleasure of two, three, maybe four people to whom this country has been very good already. And the trade is permanent, with the effects thereof visited even unto the fourth, fifth, and sixth generations.

I sometimes think of that old man I met and whether, if I were to meet him again, I would ever be able to persuade him of my point of view about the foothills. I doubt it. The problem is that he and his boss (who has since gone to his reward), like the good people who proposed Bridle Ridge, were up against a new cultural paradigm, and adjusting to these can be very hard. At least I hope the new paradigm has arrived. The special challenge of creating open space in the foothills is that the issue does not yet have the cachet of open space on the coast. This is so, even though the foothills are arguably richer in biological diversity and certainly a more immediate visual presence in our everyday lives. The inertia of the old paradigm – that development is inevitable and you might as well accept it – is still very powerful in these uplands, grounded as it is in rights of property that are, in their turn, deeply embedded in our culture. There is certainly no revolution in the making, but, in American democracy, values have always been weighed against rights. It is a complex process, yet in this instance the values that support open space are catching on like a fire. To many they seem unassailable.

Picture 4: San Marcos Foothills from Santa Barbara's Campanile Hills. Photo by Thomas Stone

11.

The Valley Oaks of Santa Barbara County

by

Frank Davis
Donald Bren School of Environmental Science and Management, UCSB

The Valley Oaks of Santa Barbara County

by
Frank W. Davis
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"We camped on Saturday, April 6, about four miles from the Mission at a little ranch owned by an American--the Ranch Alamo Pintado. It was a lovely spot. Large oaks scattered here and there, the green grass beneath, and the great profusion of flowers, made it look like a fine park. There are two species of oaks here. One is an evergreen, with great spreading branches, gnarled and knotted trunks, worthless for timber because it is never straight and it has so many branches, but beautiful, as a tree, with its dark green foliage. The other is a deciduous tree. Like the first it branches low down, so it, too, is useless for timber. It is a most beautiful tree, however, the large limbs branching in great curves--not Gothic arches like the elm, but great round curves, great Roman arches of thirty to fifty feet span, coming down again near the ground. Sometimes such a limb will be thirty feet high twenty or thirty feet from the tree, and again near the end almost touch the ground. A tree close by camp, under which I wrote on Sunday, had a head of over a hundred feet in diameter, and the trunk was about fifteen feet in circumference in the smallest place below the branches. A trailing lichen hangs from every branch, delicate as lace, of a greenish gray color, swaying with every breeze--the effect is beautiful."

Up and down California in 1860-1864; the journal of William H. Brewer, entry dated April 10, 1861

When he wrote these words 140 years ago, William Brewer was camping north of the small town of Los Olivos in the upper Santa Ynez Valley of Santa Barbara County. Brewer was describing the evergreen Coast live oak (*Quercus agrifolia*) and the decidous Valley oak (*Q. lobata*), the most common and widespread aborescent oaks of northern Santa Barbara County. Had he been camping just a kilometer or two to the east on what is now the UCSB Sedgwick Reserve, Brewer might have also noted another deciduous oak, the Blue oak (*Q. douglasii*), which is at the southern edge of its range in the upper Santa Ynez Valley.

Oak woodlands are only one element in the complex vegetation mosaic of northern Santa Barbara County foothills. These environments also support extensive areas of grassland, coastal sage scrub, chaparral, serpentine shrubland and grassland, and closed oak forests. Nevertheless, the "foothill woodlands" of Valley oak, Coast live oak and Blue oak have received a disproportionate amount of attention from travelers, scientists, artists, and writers. These open woodlands are emblematic of the California ranching landscape and a focus of much research and conservation action not only in Santa Barbara County but throughout their distribution.

The purpose of this brief essay is to give an overview of regional and local status and trends the Valley oak and its associated ecosystems. Unique to California, this oak is also one of California's most familiar and evocative icons. Ironically, the Valley oak has also been more impacted by human activities than any other oak in the State, and recent research indicates that the species is in demise over much of its range. Many counties including Santa Barbara have adopted or are considering strong Valley oak conservation measures that have stirred angry debates among environmentalists and agricultural and development interests (an excellent resource for current information on oak ecology and management is the University of California's Integrated Hardwood Management Program site, http://danr.ucop.edu/ihrmp/).

Most of the material that follows is taken from Section 1 of a recent report to the Santa Barbara County Department of Planning and Development on the distribution of oak woodlands in northern Santa Barbara County (Davis, et al., 2000). The full report is available online at http://www.biogeog.ucsb.edu/projects/sboak/final_report/toc.htm.

Valley Oak Distribution

There are more than 600 species of oaks in the northern hemisphere. Twenty species of tree and shrub oaks occur in California, including five endemics. All California oaks generally occur below 7500 ft, most at < 4000 ft, where they can be canopy dominants of chaparral, foothill woodland, and montane forest ecosystems. The Valley oak is among the largest and longest lived of the North American oaks, attaining trunk diameters up to 4 m, heights of 12 to 25 m, and ages of 300 years or more. The wood of the Valley oak is brittle and will crack and warp during drying. Thus, despite its large size and relatively rapid growth, the tree has little commercial value. Historically it was used for charcoal, firewood, and wine barrels, and its acorns were a staple food for many native Californian cultures including the Chumash of the Santa Barbara region. Valley oak woodlands and savannas support an extraordinary diversity of wildlife species, for example providing habitat for at least 67 nesting bird species (Barry Garrison, Unpublished Data).

Valley oak occurs mainly in the Central Valley and surrounding valleys and foothills, ranging from near Shasta Lake to the Santa Monica Mountains. The species is generally restricted to deep loamy soils at elevations less than 600 m, but some populations occur above 1500 m in Southern California (Griffin and Critchfield 1972). The savanna community type is found on alluvial soils of valley floors and some broad ridge tops throughout the Coast Ranges. Denser riparian stands are found along the margins of rivers, especially in the Central Valley. Valley oaks are not found in valleys directly exposed to coastal winds, as the species is sensitive to salt aerosols (Ogden 1980).

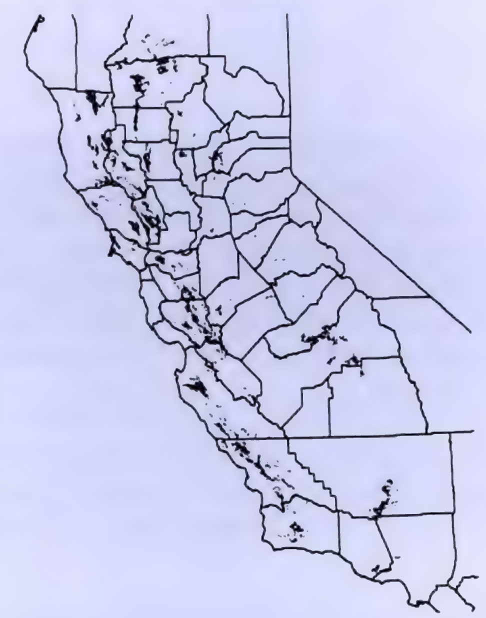
Valley oaks occur mainly in five general land use/land cover settings: 1) Valley oak and mixed oak riparian or gallery forest; 2) Valley oak and mixed oak woodland and savanna; 3) upland mixed oak and mixed evergreen forest; 4) as relict trees in improved pastures, croplands, orchards and vineyards; and, 5) as relict trees in residential and developed recreational areas (e.g., golf courses, county parks, etc.). Throughout much of its range, Valley oak occurs in sparser savannas, in smaller remnant woodlots and riparian stringers, as a minor component of other hardwood communities, or as isolated relict trees.

Despite recent, ambitious and well-designed efforts to inventory California's hardwood rangelands (e.g., Pillsbury et al., 1991; Pacific Meridian Resources, 1994), we lack complete statewide estimates of Valley oak distribution, status, and trends in all except perhaps the upland woodland types. This is mainly because current vegetation classification and mapping systems only register Valley oaks in woodland and forest vegetation when the species attains canopy cover levels greater than 10% over areas larger than 40-100 acres (Table 1.1). Throughout much of its range, Valley oak occurs in sparser savannas, in smaller remnant woodlots and riparian stringers, as a minor component of other hardwood communities, or as isolated relict trees. Thus, from the perspective of assessing the species' status and trends, a large fraction of remaining Valley oak populations is excluded from existing monitoring efforts. Some counties are conducting more detailed inventories, but there is no consistency among the local and statewide mapping efforts that would allow regional- or range-wide assessments.

Table 1: Statewide estimates of Valley oak Woodland

Source	Canopy Cover Class (%)	Acres	%Private
Bolsinger (1988)	>10%	274,000	86
Pillsbury et al. (1991)	All	251,000	90
	0-10	106,000	
	10-33	89,000	
	10-34	49,000	
Davis et al. (1998)	>10%	227,734	95
Pacific Meridian Resources (1994)	All	73,169	

Figure 1: Areas in which Valley oak occurs as a dominant or co-dominant of upland vegetation over at least 10% of the landscape (California Gap Analysis project, Davis et al. 1998).



Statewide patterns of Valley oak Regeneration

For over thirty years ecologists have called attention to the apparent lack of regeneration of Valley oaks due to drought, rodent and insect damage, and grazing by cattle (e.g., White 1966, Griffin 1971). A systematic statewide analysis of Valley oak regeneration was conducted as part of a California hardwood inventory by the USDA Forest Service during the mid-1980's. Only 120 Valley oak stands were sampled, and these included public or private lands supporting at least 10% tree cover, thus excluding sparse Valley oak savannas. Nevertheless, Valley oak appeared to exhibit the lowest levels of regeneration of the three widespread deciduous oak species of the foothill woodland system. The lack of regeneration in uplands contrasts with riparian settings in which the species appears to recruit seedlings and saplings much more readily.

Adams, et al. (1992) compared Valley oak seedling establishment at seven widely distributed sites from Mendocino to San Luis Obispo Counties and observed low seedling survivorship (average 7-13% survival after 2 years). Survival increased markedly (42-43%) when weeds were controlled and seedlings were protected from rodents.

There are several additional studies of Valley oak regeneration in other foothill woodland sites that generally support the idea that rodents and competition from exotic grasses strongly impact Valley oak seedling survivorship during the first few years. The study by Bernhardt and Swiecki (1997) is one of the few that has monitored survivorship over a longer period (6 years) in both grazed and ungrazed areas. In that study, high (>80%) survival rates were observed for mulched seedlings that were protected from cattle in grazed pastures, and lowest (<25%) for non-mulched seedlings in ungrazed areas. Similar research is currently underway at UCSB's Sedgwick Reserve.

The existing literature and ongoing studies provide some information on factors affecting Valley oak regeneration at the acorn to small sapling stages. Unfortunately, we lack longer term experimental studies that would help understand factors that are preventing the recruitment of tree-sized individuals from small saplings.

A Statewide perspective on Loss of Valley oak Habitat

For decades, scientists have raised concern over the loss of Valley oak habitats. Because they occur on deep, fertile soils, Valley oaks have been actively cleared for agriculture and urban development for 200 years. Now virtually all Valley oak plant community types are considered threatened and of high priority for inventory by both the California Department of Fish and Game and by The Nature Conservancy (California Department of Fish and Game 1997).

Between 1945 and 1973, roughly 900,000 acres of oak woodlands in California were cleared for range improvement and another 100,000 were converted for development (Bolsinger, 1987). Between 1973 and 1987, over 200,000 additional acres of oak woodland were converted to nonforest, and predictions of future loss run as high as another quarter million acres by the year 2010 (Bolsinger, 1988). Valley oak habitat may be especially vulnerable because it is not well represented on public lands or in existing reserves, and the remaining distribution coincides with areas that are predicted to undergo rapid development in the future. Bolsinger (1988) estimated that 20% (40,000 ac) of the oak woodland conversion between 1973 and 1987 occurred in Valley oak woodland, a substantial fraction given the limited area in this type.

Estimates vary, but perhaps 90% of remaining Valley oak woodland is privately owned (Table 1.1), and less than 5% of Valley oak woodland is in formally designated reserves, with protection concentrated in Monterey and Santa Clara Counties (Greenwood 1993, Davis et al. 1998). Similarly, only 4-5% of Valley oak Riparian Forest is in reserves (Davis et al. 1998).

Table 2: Buffer widths assigned to road classes for calculating roadedness index (from Davis, et al., 1998).

Census Feature ClassCode	Description	Buffer width (m)
A10-A18	Primary road with limited access or interstate highway	500
A20-A28	Primary road without limited access (US and state highway)	250
A30-A38	Secondary and connecting road (state and county roads)	100
A40-A48	Local, neighborhood, or rural road	100
A50-A53	Vehicular trail (4 wheel drive route)	25

Using County-level population projections, land ownership, proximity to roads, and distance from existing population centers, Davis, et al. (1998) developed a rough measure of threat for major plant communities in California. This analysis suggests that remaining Valley oak woodland is more threatened than other widespread foothill woodland community types. Using the 1990 1:100,000 scale TIGER files produced by the Bureau of Census, they estimated the fraction of each plant community's mapped distribution that is influenced by roads by buffering road segments with a buffer width related to the class of road (Table 2).

County-level population projections through the year 2020 AD were obtained from the California Department of Finance (1997). By assuming that development associated with population growth will occur on private land near existing urban areas and to a lesser extent along major road corridors, Davis, et al. (1998) produced a simple GIS-based model to predict the increase in human population density in each major plant community type. As summarized in Table 3, Valley oak woodland appears from this analysis to be more impacted by roads and more vulnerable to future development than any other major foothill woodland type in California.

Table 3: Surrogate measures of threat to oak woodlands in California (see Davis et al. 1998 and text for explanation).

	% in Road Buffer	Projected pop growth (#/km²)
Valley oak	**27**	**26**
Blue oak	13	18
Interior live oak	18	21
Oregon oak	4	21
Foothill pine-oak	17	20

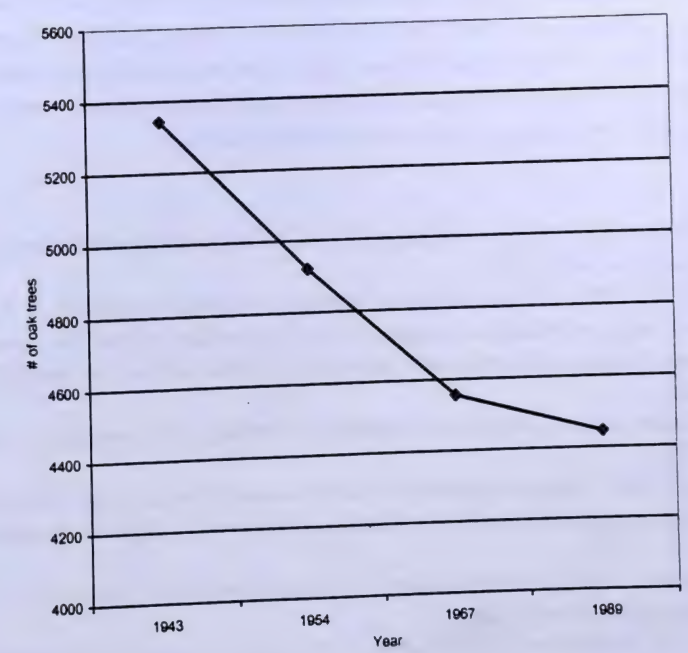
Valley oak in Santa Barbara County

Smith (1998) describes the distribution of Valley oak in the County as commonly scattered in valleys from Santa Ynez to Los Alamos, in the lower Cuyama Valley, and into foothills and mountains to around 4500 ft. The species also occurs on Santa Cruz Island.

The County has been included in the statewide mapping efforts described above, but these sources disagree considerably on the location and extent of remaining Valley oak woodland and savanna. The need for such information has arisen with the rapid changes in land use in the Santa Ynez and Los Alamos Valleys, including large scale conversion of Valley oak and mixed oak savannas to vineyards as well as rural residential development (Gira et al. 1999).

Despite ample acorn and seedling production, tree cover and density in remaining Valley oak populations are declining in Santa Barbara County. In the Santa Ynez Valley, Brown and Davis (1991) used archival air photos to document a 21% decline in the number of overstory Valley oaks between 1938 and 1989. No new trees established in the twelve surveyed populations during this time period.

Figure 2. Decline in overstory oaks in twenty-one stands of Valley oak or Mixed oak woodland and savanna at UCSB's Sedgwick Reserve (near Los Olivos, CA), 1943-1989, based on analysis of archival air photos.



At UCSB's Sedgwick Ranch Reserve near Los Olivos, Dennis Odion, Bruce Mahall, and I used archival air photos to monitor twenty-one areas supporting Valley oak and mixed oak woodland. The number of overstory oaks declined from a starting population in 1944 of 5343 individuals (roughly half of which were Valley oaks) to 4446 trees in 1989, representing a 19% decline in tree density over the period (Figure 2).

Although I have observed some rangeland sites in Santa Barbara County where Valley oak seedlings and saplings are plentiful, these sites are rare, and the only environments where Valley oaks are recruiting in abundance are along roadsides. These roadside areas have been ungrazed for many years and may also be receiving supplemental runoff from the road surface. Changes in other mortality factors such as rodents, weed competition, and deer may also contribute to this pattern.

In 1994, UCSB researchers Bruce Mahall, Claudia Tyler, and I, funded by Santa Barbara County's Energy Division, initiated a long term experimental study of factors affecting Valley oak recruitment in Santa Barbara County (see http://www.biogeog.ucsb.edu/projects/oak/ for details). This study is designed to isolate the effects of small rodents versus large grazers and browsers, including cattle, and is aimed at developing low-cost methods for restoring Valley oaks in existing rangelands of the County. There has not yet been enough time in this study to evaluate long term patterns of seedling and sapling survival. However, data on seedling establishment over the first few years are consistent with findings from previous studies in indicating the importance of small rodents (especially gophers) as agents of seedling mortality. It is also worth noting that cattle grazing as it is being practiced on Sedgwick Reserve (winter-spring grazing only) appears to have only a minor effect on seedling establishment.

Summary

Valley oak woodlands and savanna are scattered over a large area of California's Central Valley and surrounding valleys and foothills. Populations in Santa Barbara County are near the southern range limit of the species in the Santa Monica Mountains. Because Valley oaks often occur at very low densities and canopy cover and are often in agricultural and residential areas, the status and trends in Valley oak are not well described by previous surveys aimed at monitoring oak woodland and forest types. Nevertheless, there is strong evidence from recent statewide surveys that the species is in decline over most of its range and is also especially vulnerable to habitat loss though land use conversion from rangeland to intensive agriculture and residential development.

As is the case elsewhere in the State, the distribution and abundance of Valley oak in Santa Barbara County has been highly modified by agricultural and residential development, cutting, and poor regeneration in remaining stands. Existing surveys of Valley oak in Santa Barbara County provide conflicting views of the distribution of the species. More detailed information is certainly needed to monitor local status and trends and to guide management, conservation, and restoration of remaining populations and their habitats.

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Plumes and Blooms in the Santa Barbara Channel

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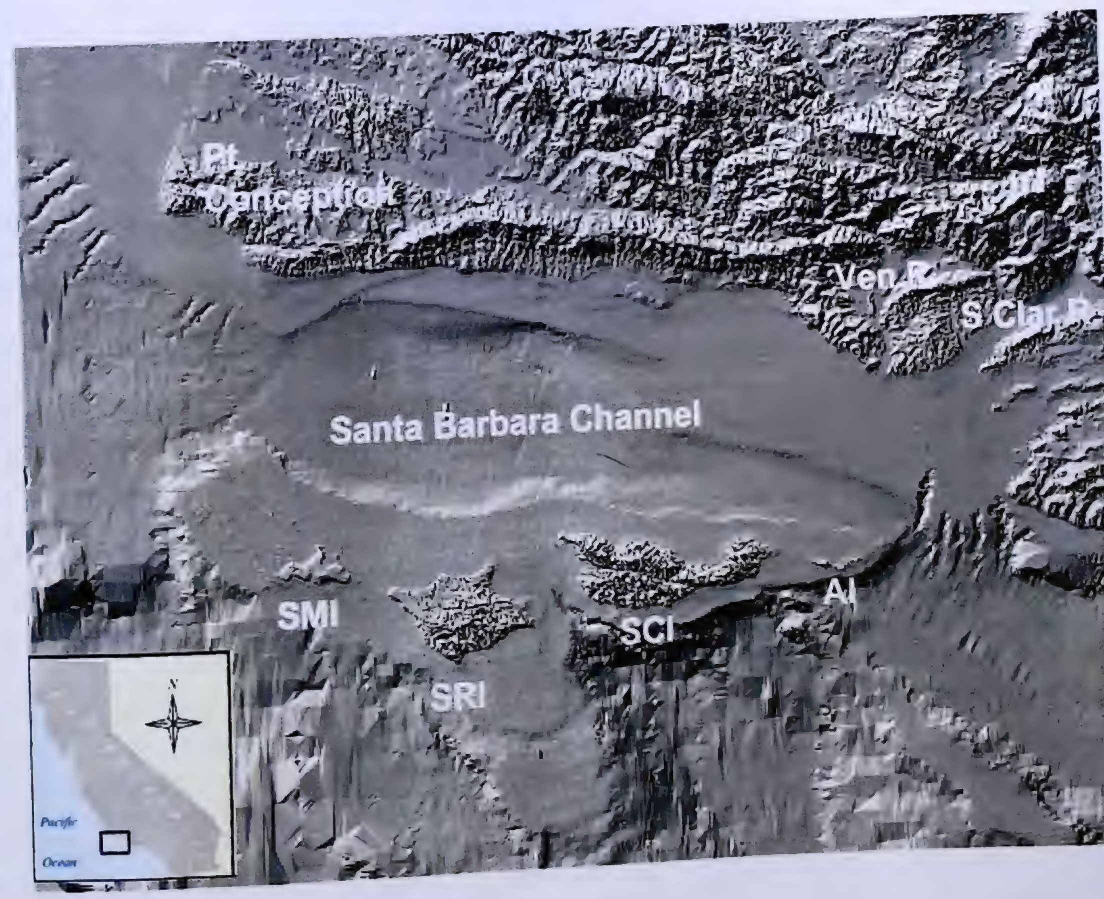
Introduction

The waters of the Santa Barbara Channel (Figure 1) change color with every season. During our rainy winters, rivers and creeks sweep sand, mud, and many other materials into the ocean. Although the turbid, brown water of the river plumes usually hugs the coastline, it may cross the Channel during very severe storms (Mertes, et al., 1998). When spring and summer arrive, algae arrive, thriving on the nutrients provided by the plumes and cold ocean water, the sun's energy, and oxygen. During this time, the waters can turn green, blue-green, and even red, depending on the types of the organisms growing in the water. These sediment plumes and algae blooms provide an outstanding field laboratory. The Plumes & Blooms Project and the Santa Barbara Coastal Long-Term Ecological Research (LTER) Program at the University of California at Santa Barbara are using field data collected from boats and bridges and remote sensing data collected from satellites and airplanes to study the characteristic patterns of ocean color and their relationship to the health of the reef and algae communities in the Santa Barbara Channel. For example, the spectral (light) properties of the remote sensing data allow us to measure the amount of sediment and algae in the Santa Barbara Channel. In particular, the patterns of the plumes and blooms help us to understand how the natural processes of erosion and photosynthesis are being affected by human-induced erosion and the transfer of excess sediment and other pollutants into the ocean.

Figure 1: Shaded relief map of topography and bathymetry of Santa Barbara Channel and surrounding watersheds. SMI = San Miguel Island, SRI = Santa Rosa Island, SCI = Santa Cruz Island, AI = Anacapa Island, Ven R. = Ventura River, and S. Clar. R. = Santa Clara River.



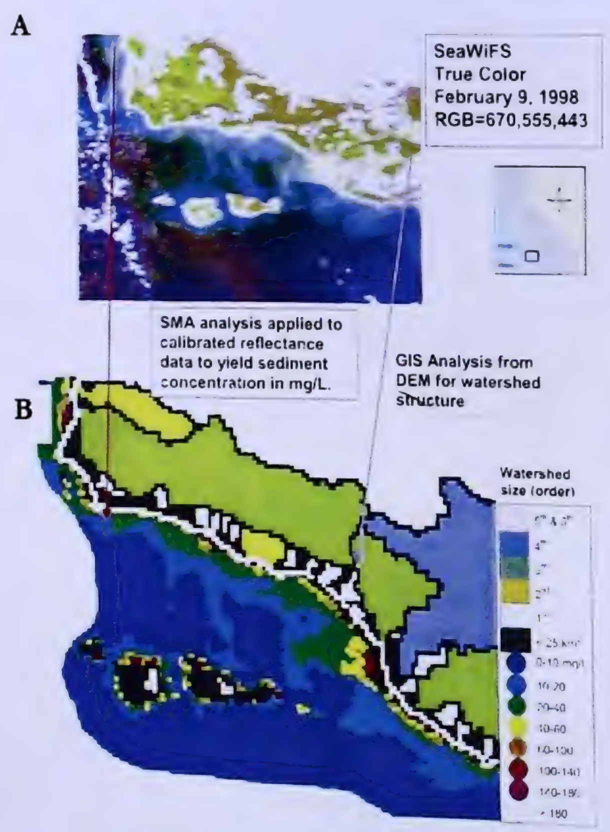
Methods

During six storm events (>3 cm rainfall), from December 1997 to February 1998, surface water samples were collected in a weighted Niskin bottle from bridges near the coast for 2-13 rivers in central California (northwest of the area indicated for the Santa Clara and Ventura Rivers in Fig. 1), filtered onto tared 0.47 □ m Millipore filters, and the filters were weighed for total suspended matter (TSM). Particle size analysis of the sediments was performed with a Micromeritics Sedigraph (Coakley and Syvitski, 1992). On February 11,1998, surface samples for TSM were collected at nine stations in the ocean within the river plume of the Santa Clara and Ventura Rivers. To characterize the vertical structure of the plume at each station, conductivity, temperature, salinity, and light transmission were measured with a Sea-Bird CTD (conductivity, temperature, and depth).

Using the SeaWiFS data we produced a map of sediment concentration in mg L^{-1} based on a methodology with calibration to laboratory data developed by (Mertes, et al., 1993). The SeaWiFS bands at wavelengths 555, 670, 765, and 865 nm only were selected to convert the surface reflectance to sediment concentration in mg L^{-1}. An error analysis of the nonlinear calibration curve produced an average predicted error for TSM of $\pm$ 10 mg L^{-1} (see Mertes and Warrick, 2001, for a more detailed discussion of these techniques and results). Further analysis of the data to produce maps of relative concentration of algae included extraction of image endmembers for high concentration of algae and analysis of the image data with the spectral mixture analysis tool described by Mertes, et al. (1993).

Each of the surface plumes was assigned to their source rivers within a Geographical Information System (GIS) analysis that combined the image data with maps of watershed boundaries (Figure 2b) that were delineated using digital elevation data and standard algorithms for terrain analysis (Mertes, et al., 1998). Ocean plumes were matched to watersheds by proximity to river mouths. To show relative size, watershed order was assigned subjectively based on the requirement that a first-order watershed is at least 25 km^2.

Figure 2: A. True color composite image of SeaWiFS data for February 9, 1998.
Figure 2: B. Calibrated SeaWiFS data overlaid onto map of watershed structure.



Analysis of Results

During 1998, California experienced the wettest February of the past 100 years (NCDC, 1998). Most precipitation stations recorded over 400% of average February monthly precipitation, with exceptions in the Sierra Madre and Northern Coastal Range which experienced over 200% of average monthly precipitation (NCDC, 1998). The storm of February 1-9, 1998 (Fig. 1) was most intense along the central coast of California (Russian River to Santa Clara River), where most stations received amounts of precipitation for a 10-year to 20-year (some up to 100-year – e.g., Monterey) recurrence interval (DWR, 1982; NCDC, 1998).

Field measurements of river TSM showed a range of sediment concentrations from 36 g L^{-1} for the Santa Clara River (drainage basin area of 4100 km^2) to a maximum of 57 g L^{-1} for Padre Juan Creek (approximate drainage basin area of 12 km^2). Texture analysis yielded a mean (5 μm) and modal (16 μm) grain size for the Santa Clara River in the silt range as reported earlier by (Inman and Jenkins, 1999). Based on our oceanographic measurements, the thickest part (5 m) of the Santa Clara -Ventura surface plume was associated with the highest measured concentration of TSM (44 mg L^{-1}), with both thickness and concentration decreasing to 1.5 m and 2 mg L^{-1} as the distance from the shoreline increased. These measurements of TSM and thickness of the surface plume are similar to data reported for the Eel River plume (Geyer et al., 2000; Hill et al., 2000), Yellow River plume (Wright, et al., 1988), the Mississippi River plume (Walker, 1996), and model results for hyperpycnal plumes (Chao, 1998).

Based on the SeaWiFS data, surface sediment concentrations ranged from open-ocean values of <10 mg L^{-1} to 180 mg L^{-1} near river mouths (Fig. 2b). The higher concentrations derived from the image data in the Santa Clara - Ventura plume, compared to our field measurements (maximum 44 mg L^{-1}), are expected because the image was acquired near the time of peak discharge for the rivers, while the field measurements in the ocean were collected two days later after some settling and dilution had occurred.

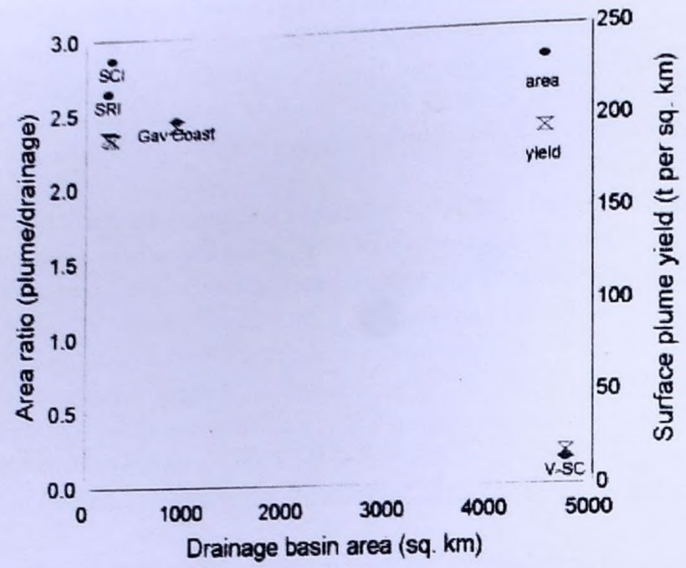
Discussion

Using the surface suspended sediment concentrations (in mg L^{-1}) derived directly from SeaWiFS data, we can examine the relationships among plume mass, plume size, and watershed size for Santa Barbara Channel region for this very wet period. In order to calculate the total mass in all the surface plumes for February 9, the thickness of the surface plume for different sediment concentrations was estimated from the field measurements made in the Santa Clara - Ventura plume. The thickest part of the plume was calculated to be 5 m for concentrations >25 mg L^{-1}, decreasing to 4 m for 10-25 mg L^{-1}, and 3 m for 5-10 mg L^{-1}. For each 1 km^2 SeaWiFS pixel, a thickness was assigned according to the concentration, and then the thickness was multiplied by the concentration and the area to yield mass in tons. For example, the combined Santa Clara - Ventura surface plume contained 82 700 t.

We also made an order-of-magnitude estimate for total sediment output from the combined Venture and Santa Clara watersheds using established sediment rating curves (Brownlie and Taylor, 1981) and reported water discharges (USGS Station 11114000 and 11118500). The total combined suspended sediment discharge for the first week of February 1998 was ~19×10^6 t compared to only 82 700 t in the plume. In other words, only 0.4% of the total suspended sediment load is observed in the surface plume. This result is not completely unexpected, because it is known that when rivers in California carry a load greater than ~25 mg L^{-1} (Mertes and Warrick, 2001) to their mouth, then the river discharge can travel to the ocean bottom almost immediately as a *hyperpycnal* (high-density) flow. These bottom currents are in contrast to the neutrally (homopycnal) and positively (hypopycnal, i.e., surface) buoyant plumes that also develop at the river mouths (Bates, 1953).

Although the total mass represented by the surface plumes in the Santa Barbara Channel on this date (354 000 t) is small relative to the total sediment discharge (>20 million tons), the areal extent was 4275 km^2 (compared to a total drainage basin area of 6115 km^2). The largest plumes extend tens of kilometers out from the coast, nearly crossing to the islands (Figure 2b). The relatively higher areal and mass impact of the smaller watersheds is observed in Figure 3. This type of relationship, where the smaller watersheds have much higher yields into the ocean, is comparable to observations for other steep, coastal drainages (Milliman and Syvitski, 1992).

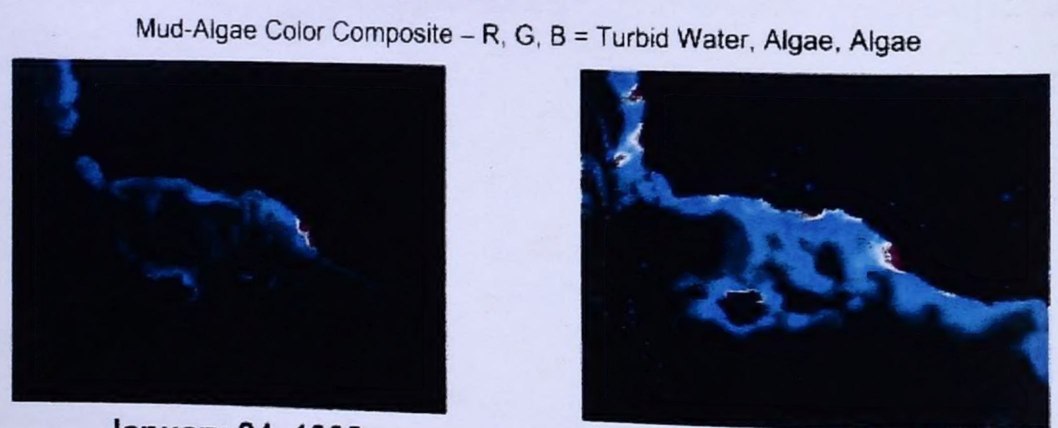
Figure 3: Comparison of drainage basin area to areal extent and mass of surface plumes.



Area ratio represents the surface plume area divided by the drainage basin area. Yield represents the ratio of the surface plume mass in tonnes to the drainage basin area. SCI and SRI as shown on Figure 1 and Gav-Coast represents all plumes from Point Conception to the Ventura-Santa Clara Rivers (V-SC) plumes.

In order to evaluate the impact of the surface sediment plumes on algae blooms, it is informative to view images that show the patterns of the concentrations of sediment and algae simultaneously. Figure 4 depicts these patterns for two dates in 1998. In the first image, early in the storm sequence, the plumes are only modestly developed, and the pattern of algae concentrations shows highest values near the coast. Approximately 2 weeks later, after over 30 cm of rain had fallen, both the plumes and blooms have expanded to cover nearly the entire Santa Barbara Channel. More detailed analysis of these types of images, combined with the oceanographic measurements will lead to a greater understanding of the physics and biology responsible for the timing of the observed spatial patterns.

Figure 4: Color composites of processed SeaWiFS data to show relative distribution of sediment and algae concentrations. Brighter red equals more turbidity and brighter cyan indicates higher algae concentrations. Rainfall amounts are for the week prior to the date of image acquisition.



January 24, 1998
1.3 cm of rain

February 9, 1998
27 cm of rain

Conclusions

The natural signal of sediment transport into the coastal waters of the Santa Barbara Channel is immense, but not easily measured because of the fact that most of the sediment arrives in huge pulses associated with severe winter storms. In addition, because of the high concentration of sediment in the water, much of the sediment load transitions to the ocean bottom almost immediately after leaving the river mouth in the form of a hyperpycnal current. These facts are confirmed by the data reported in this paper, wherein, field and remote sensing data show that for a severe storm period associated with El Niño climate conditions in 1998:

1. Many rivers and creeks are transporting loads in excess of 30 g L-1 during high flows.
2. Less than 1% of the total sediment discharged by rivers for the storm sequence leading up to February 9, 1998 (>20 million tons) is present in surface plumes (~82 700 t) observed with remote sensing data for that date.
3. Despite the relative paucity of sediment mass in the surface plumes, river water mixed with ocean water, with concentrations ranging up to 140 mg L^{-1}, covered ~4300 km^2 of the Santa Barbara Channel.
4. The small creeks along the Gaviota Coast and on Santa Cruz and Santa Rosa Islands had a relatively high impact on their local coastal waters because of the high water and sediment yields associated with their steep, mountainous drainage basins.
5. Remote sensing data of algae blooms show the distinctly different patterns associated with coastal river plumes and provide the type of information that will be informative for evaluating the health of our coastal waters.

Acknowledgements

NASA, NOAA, and NSF research support provided. We thank personnel of the NOAA Channel Islands National Marine Sanctuary and crew of the R/V Ballena for field activities. We thank J.M. Herman and C. McKenzie for laboratory assistance. SeaWiFS data are the property of the Orbimage Corporation and are used here in accordance with the SeaWiFS Research Data Use Terms and Conditions Agreement of the NASA SeaWiFS Project. The Plumes and Blooms study is a joint collaboration between the NOAA Channel Islands National Marine Sanctuary and the University of California, Santa Barbara, in cooperation with several research groups and other federal, state, and local agencies. The Santa Barbara Coastal LTER is supported by NSF.

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Santa Barbara County - Geospatial Data Resources Available Through The Map And Imagery Laboratory

by
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Introduction

The Map and Imagery Laboratory (MIL), part of the Davidson Library at UCSB, promotes interdisciplinary use of spatial data and provides technologies for integrating diverse information formats. The 12,500 square-foot facility is unique among academic libraries in the quantity of spatial data held and the availability of equipment used for analyzing analog and digital materials; in 1992 MIL was ranked the number-one spatial-data collection in the top 100 members of the Association of Research Libraries. It is the home of the Alexandria Digital Library (ADL), which, via the ADL Catalog (http://webclient.alexandria.ucsb.edu), provides access to ca. 2.5 million catalog records and 4 terabytes of geospatial data.

MIL serves the academic and research needs of the University of California (UC). It also has clients from other academic institutions and commercial firms. Since it began in 1967, and especially since its move to larger quarters in 1979, MIL has been a focus for regional, national, and global academic research. Its collections of maps and remote-sensing images (air photos; satellite images) currently exceeds 4.5 million information objects and continues to increase in number.

The Collections

Even though UCSB is a major research university hosting multi-national collections, a sizable percentage of reference questions asked focus on southern California generally and Santa Barbara County specifically. Of the 2.8 million United States aerial photographs available, about half are of southern California. The 1.2 Landsat satellite images of the 1972-1978 archival collection are world-wide coverages of continental land surfaces. Recently, in partnership with its fellow UC map libraries, MIL has purchased SPOT Image and Landsat 7 coverage for all of California. In early 2001, MIL purchased examples of IKONOS 1-meter coverage (covering the area of the two most heavily used maps in the entire collection - the U.S. Geological Survey 7.5-minute topographic quadrangles, Santa Barbara and Goleta); MIL is also planning on purchasing IKONOS coverage for larger areas.

The map collection of 480,000 sheets is principally composed of medium- and large-scale topographic sheets of the United States and foreign countries, with a strong secondary collection of nautical charts. The UC libraries are in the very fortunate position of being a complex of nine libraries, so no one library is compelled to collect all relevant materials. The UC/Stanford Map Libraries Group - in existence since the early 1970s - coordinates collecting by taking responsibility for areas' strengths (both geographic and thematic). For example, MIL collects very little detailed geologic mapping (except for southern California), since Stanford, UCB, and UCLA each have excellent large-scale, geologic-map collections. MIL also collects very few historic maps other than facsimiles, because of the superb pre-1900 map collections held at the Bancroft at UCB, and at Stanford and UCLA. MIL's collection strengths include in-depth, multi-subject coverage of Santa Barbara County.

MIL's digital-data collection is in many forms, including thousands of CD-ROMS plus about four terabytes of online data. This growing collection is comprised of aerial photographs (scans of photos held by MIL), DRGs (Digital Raster Graphics) of California, DOQQs (Digital Orthophoto Quarter Quads) of California, and selected GIS and satellite coverages.

Services and Facilities

MIL's hardcopy collection continues to be extensively used; therefore our clients may avail themselves of light tables, magnifying glasses, and stereoscopes. These essential components are distributed throughout the user area. MIL's Computer Lab supports student and faculty research by providing workstations, digitizing and scanning hardware, and a wide selection of media devices such as tape drives and CD writers. MIL's software support in-

cludes GIS and Image Processing applications such as Arc/info, Arcview, Imagine, Autocad, and Adobe Acrobat. MIL's staff each has a specialty, ranging from photo-interpretation and cartography to image-processing and GIS applications. MIL staff are available to help clients get started using the collections and applications, but do not teach extended classes in application technologies.

There are no service fees for UC users conducting their academic research. There are fees for non-UC user services. These cost recovery services include access to the remote-sensing images in the collection, access to digital materials, and labor associated with digital services. Special educational licensing restrictions for data and software, and hardware vendors, preclude the use of copyrighted data by non-UC users and the use of selected software. There is a computer workstation specifically set aside for use by non-UC users. There is no charge for use of hardcopy maps and atlases.

Alexandria Digital Library (ADL)
Between 1994 and 1998, UCSB was awarded an NSF/DARPA/NASA Digital Libraries Initiative (DLI) grant -# one of six - to develop the Alexandria Digital Library. All of the objects in the digital library are geographically referenced; that is, they are associated with one or more regions on the surface of the Earth. ADL currently provides access to the Internet community, a growing subset of MIL's holdings, as well as other geographic datasets located within other archives. The components of this online information system may be spread across the Internet or reside on a single desktop. In addition to the ADL datasets, the grant allowed for the construction of a 4.5-million – entry place name database to assist in spatial data searching and geo-coding. The ADL Catalog now has approximately 2.5 million records, pointing to about 1.9 million hardcopy items (chiefly Landsat satellite images, sheets in map series and air-photo flights) and 4 terabytes worth of digital data (primarily aerial and satellite photographs, U. S. Geological Survey base-date products, and a growing set of GIS layered products).

The current ADL research project is ADEPT (Alexandria Digital Earth Prototype). ADEPT's research group is comprised of a consortium of researchers, developers, and educators spanning the academic, public and private sectors, exploring a variety of problems related to a distributed digital library for geographically referenced information.

The vision for ADL's future encompasses unlimited accessibility to all information that may be spatially referenced. Please visit our Web page for more information at http://www.alexandria.ucsb.edu/ and try out the gazetteer and catalog services. These services are part of the UC Santa Barbara's Davidson Library (see Web address below).

Contact Information:

Email: mil@sdc.ucsb.edu
Web: http://www.sdc.ucsb.edu/
http://www.alexandria.ucsb.edu
http://www.library.ucsb.edu

Appendix

SANTA BARBARA COUNTY COVERAGE IN DIGITAL FORM
By definition, any database or dataset that covers all of the United States or the entire world - such as the Digital Chart of the World - covers California. Usually, though, such datasets are derived from relatively small-scale (e.g., 1:1,000,000) data, and therefore many have not been included in this list. MIL's "Spatial Data in Digital Formats" list is a more complete list of our entire digital data collection in which you may find U.S. and world-wide coverage. Since this list is only of Santa Barbara County, it is divided up according to shelf location - that is, by digital format (CD; diskette; magnetic tape on reels, or cassettes). MIL's reference staff are available to assist you in finding datasets. Increasingly, MIL is moving higher use items online.

TIGER files are the boundary-line files for the 1990 Census; as of May 2001, the 2000 Census files have not been received - for most current information, see http://www.tiger.gov. They were digitized from 1:100,000-scale planimetric sheets; MIL has them in several different editions. Demographic data on CD for the 1990 Census are contained in the STF files on CD-ROM; check at the library's Government Publications Information Center.

ONLINE materials

Aerial photographs of southern California - ca. 40,000 frames as of 5/2001
DOQQs of California
DRG (Digital Raster Graphics)
Landsat 7 coverage of California
SPOT imagery coverage of California

OFFLINE digital data

CD-ROMs
DLG - 1:100,000-scale Digital Line Graph Data
Call no.: 3700s 100 .U544 hy/tr CD
DRG (Digital Raster Graphics)
Spot Imagery Coverage of California
Call no.: 3201 A4 1994 .S6 CD
TIGER/Line Precensus Files, 1990
Call no.: 3700s 100 .U542 CD ANNEX (except for CA)
TIGER/Line Census Files, 1990
Call no.: 3700s 100 .U543 CD ANNEX (except for CA)
TIGER/Line Census Files, 1992
Call no.: 3700s 100 .U543 1992 demographic and economic data (e.g., County city data book) CD
TIGER/Line Census Files, 1994
Call no.: 3700s 100 .U543 1994 demographic and economic date (e.g., County city data book) CD
TIGER/LINE 1995
Call no.: 3700s 100 .U543 ed. 1995 CD
Wessex TIGER 92 U.S. Streets and Boundaries
3700 1992 .W4 CD
Wessex TIGER 92 Sampler
3700 1992 .W4 Sample CD
Wessex STF 1a
3700 1992 .W4 STF1a CD
National Wetlands Inventory
Call no.: 3701s D2 VAR .U5 CD
TIGER/Census Tract Street Index
Call no.: 3701 P2 1990? .U5 CD
DeLorme Street Atlas U.S.A.
Call no.: 3701 P2 YEAR .D4 CD
Wessex Tiger 94
Call no.: 3701 P2 1994 .W4 CD
Streets Plus
Call no.: 3701 P2 1997 .M5 CD
Wessex
Call no.: 3701 P2 1997 .W4 CD

Hiking and biking in Santa Barbara

by
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The best place for information is:

Pacific Travellers Supply
12 West Anapamu
Santa Barbara, CA 93101
805-963-4438
www.pactrav.com

They carry topographic maps (on paper and on CDs) and hiking and travel supplies, along with globes and atlases to delight a geographer. Here are a few of the inexpensive books you can find there:

R. Ford – Santa Barbara Day Hikes
R. Ford – Santa Barbara Mountain Biking
Sierra Club – Santa Barbara Trail Guide
S. Edwards – Rock Climbing: Santa Barbara & Ventura
K. Bridgers & C. Crabtree – Insiders Guide to Santa Barbara

Across the street at 21-22 Anapamu is the Karples Manuscript Museum.

Also try the UCSB bookstore.

Anapamu [Ana-pa-mu] is just off State Street in downtown Santa Barbara.
It is possible to travel from UCSB to downtown Santa Barbara by bike, much of the way off of streets.

Enjoy